ACTA UNIVERSITATIS SZEGEDIENSIS

ACTA BIOLOGICA

NOVA SERIES

TOMUS XXXIV FASCICULI 1—4

SZEGED (HUNGARIA)
1988

ACTA UNIVERSITATIS SZEGEDIENSIS

ACTA BIOLOGICA

NOVA SERIES

TOMUS XXXIV FASCICULI 1—4

SZEGED (HUNGARIA)
1988

Kiadja

a Szegedi József Attila Tudományegyetem Természettudományi Kara

(Szeged, Aradi Vértanúk tere 1.)

ISSN 0563—0592

Kiadványunk rövidítése

ACTA Biol. Szeged.

ACTA BIOL. SZEGED. 34. PP. 3 (1988)

PROFESSOR ISTVÁN SZALAI IS 75 YEARS OLD

Emeritus Professor ISTVÁN SZALAI, one of the pioneers of plant physiological research, the founder and first head of the Department of Plant Physiology of Szeged University was born in 1913. In 1939, after finishing his studies at the university he became the colleague of Professor PÁL GREGUSS at the Department of Botany. He worked in several fields of the botanical sciences, his interest however soon turned towards plant physiology, because he recognized the promising tendencies of the development of this branch of science.

Following the organization of the Department of Plant Physiology he worked on the establishment of teaching plant physiology, and scientific research. The sign of his substantial work in the field of education is the fact, that he is the author resp. co-author of six textbooks. A modern research field: the regulation of plant growth and development, is one of the main research topic of the department even now. He published his results in several Hungarian and international journals.

ISTVÁN SZALAI was a man of scientific public life, partly at the university, partly at the Hungarian Academy of Sciences. He was also active as technical editor between 1957—64, then editor in chief between 1967—1974 in the Editorial Board of Acta Biologica, and also as the member of Botanical Committee of Hungarian Academy of Sciences as well as member of the National Postgraduate Degree Granting Board. Professor SZALAI was invited to the Budapest University of Horticulture in the 70-es, to give lectures on plant physiology, and he has been a professor there continuously after his retirement too.

We wish successful work and good health to Professor SZALAI.

the Editorial Board

ACTA BIOL. SZEGED. 34. PP. 5—6 (1988)

IN MEMORIAM DR. ARANKA STAMMER
(1928—1988)

The retired Associate Professor of the Department of Zoology, our beloved ARANKA, as everyone knew her, died unexpectedly at the age of 60.

She was an outstanding teacher, a research worker with original ideas and a warm-hearted friend and colleague.

She was born on 15th March, 1928, in Kistelek. She began her studies at the Faculty of Natural Sciences of the University of Szeged in 1947, where she read biology and geography. She graduated in 1952, but already in 1951 she was employed as a teaching assistant at the Department of Botany. She began her teaching career at the Department of Zoology, and she remained a member of this department until her retirement on 31st December, 1984. She was first an instructor, then became a Scientific Researcher of the Hungarian Academy of Sciences (from 1970 a Senior Research Fellow) and in 1975 she was appointed to be Reader of the Department. She received her doctoral degree in 1958, and her degree of candidate in biological science in 1966.

She always laid emphasis on teaching, whatever her title was. Her talents in pedagogy and her excellent knowledge of her scientific fields will always be remembered by her colleagues and former students.

She showed her versatility by being able and willing to teach almost every branch of Zoology: taxonomy, human anatomy, physiology, etc. As she felt dedicated most of all to zoological anatomy, she later taught this subject exclusively. She contributed to the writing of numerous university coursebooks, many of which are still used in the curriculum.

Her research work focused on the neurohistology of vertebrates. During the last years of her research activity, she became interested in environmental problems: she studied the structural changes caused in the gill of fishes by water pollution. She

gave accounts of her results in 58 scientific papers. She delivered lectures at numerous congresses in Hungary and at eight international meetings abroad.

She was a member of the Hungarian Biological Society, the Society of Hungarian Anatomists, Histologists and Embryologists, the International Endocrinological Society and the International Ichthyological Society.

Her accomplishments made an inestimable and lasting contribution not only to our department and university, but to the general scientific life in Hungary and abroad as well.

Dr. I. Benedeczky

BIBLIOGRAPHY OF ARANKA STAMMER

S, A. and ÁBRAHÁM, A. (1954): Pressoreceptoren in der Wand der Schwimmblase. — Ann. Biol. Univ. Hung. *2*, 345—360.

S, A. and ÁBRAHÁM, A. (1954): A madarak szemmozgató izmainak beidegzése, tekintettel a ganglion ciliare szerkezetére. (Innervation of outer eyeball muscles with particular attention on the structure of ganglion ciliare). — Állattani Közl., *44*, 115—134.

S, A. (1956): A ganglion ciliare szerkezete és cholinesterase aktivitása. (The structure of ganglion ciliare and its cholinesterase activity). — Acta Biol. Szeged. *2*, 219—234.

S, A. (1956): Beitrage zur Kenntnis des Ganglion ciliare des Hundes. — Acta Biol. Szeged. *2*, 219—234.

S, A. and ÁBRAHÁM, A. (1957): Die mikroskopische Innervation des Vogelherzens. — Acta Biol. Szeged. *3*, 247—274.

S, A. (1957): Az édesvizi csontoshalak szemizmainak mikroszkópikus beidegzése. (The innervation of outer eyeball muscles of freshwater teleosts) — Állattani Közl. *46*, 115—123.

S, A. HORVÁTH, I., MINKER, E. and ERDÉLYI, L. (1958): The structure of the peripheral transmission apparatuses and the forms of their connection. — Acta Biol. Acad. Sci. Hung. Budapest, Suppl *2*, 32.

S, A. and ÁBRAHÁM, A. (1959): Untersuchungen über die Structur, die mikroskopische Innervation der Augenmuskeln von Reptilien. — Acta Biol. Szeged. *5*, 129—141.

S, A. (1959): The structure and microscopical innervation of the suprarenal glands in Reptilies. — Acta Biol. Szeged. *5*, 115—224.

S, A. (1961): Nervenorgane der Vogelhaut. — Acta Biol. Szeged. *7*, 115—131.

S, A. (1962): Nervenverbindungen in der Tunica vasculosa. — Acta Biol. Szeged. *8*, 143—159.

S, A. (1963): The microscopic innervation of the urinary bladder in lover vertebrates. — Acta Biol. Szeged. *9*, 263—272.

S, A. (1964): Ein Beitrag zur Struktur und mikroskopischen Innervation der Harderschen Drüse der Vögel. Acta Biol. Szeged. *10*, 182—195.

S, A. (1965): Histological and histochemical examinations on the ciliary ganglion of mammals. — Acta Biol. Hung. *5*, 93—107.

S, A. (1965): Die mikroskopische Struktur des Ganglion ciliare der Frösche. Acta Biol. Szeged. *11*, 119—124.

S, A. and ÁBRAHÁM, A. (1966): Über die Struktur und die Innervierung der Augenmuskeln der Vögel unter Berücksichtigung des Ganglion ciliare — Acta Biol. Szeged. *12*, 87—118.

S, A. (1966): The microscopic innervation of the gill-apparate in *Scorpaena porcus*. Acta Biol. Szeged. *12*, 101—114.

S, A. (1969): Comparative investigations on the ciliary ganglion of fresh-water fishes. Acta Biol. Szeged. *15*, 101—110.

S, A. (1973): Data to the electron microscopic structure of the pineal organ of the birds. — Acta Biol. Szeged. *19*, 161—176.

S, A., CSOKNYA, M. and HORVATH, I. (1975): The site and structure of the receptors in the digestive tract of fowls. — 10. Congress of the European Association of Veterinary Anatomists. — Abstracts. (Bp., 4—6. Sept., 1975).

S, A. and ÁBRAHÁM, A. (1976): Comparative light and electron microscopic investigations on neurosecretory cells. (Abstract) — Int. Symp. Neurosecretory Cells. Leningrad, 1976. 7. p.)

S, A. and HORVÁTH, I. (1979): Electron-microscopical structure of gill lamellae of the ide *(Leuciscus idus)*, with particular regard to the chloride cells and H_2S pollution. — Acta Biol. Szeged, *25*, 133—142.

S, A. (1979): The structure of gill cells in relation with genetic of *Leuciscus idus*. — 8. Ichtiol. Conf. Warsawa, Sept. 26—29. 1979. (Abstracts, 56. p.)

S, A. and HORVÁTH, I.: Special mitochondrial transformation in the inner segment of visual cells. — Acta Biol. Szeged. *25*, 85—95.

S, A., HORVÁTH, I. and CSOKNYA, M. (1980): A dikonirt hatása a földigiliszta *(Lumbricus terrestris)* bélhámsejt organellumaira. (Effects of diconirt on the organelles of the epithelial cells of the gut in

the earthworm (*Lumbricus terrestris*). — A Nehézvegyipari Kutató Intézet közl. Veszprém, *10*, 273—278.

S, A., HORVÁTH, I. and CSOKNYA, M. (1982): Elváltozások a halvese cytoplazmatikus organellumain kénhidrogénes szennyeződéssel. — Changes in the kidney cytoplasmatic organelles as a result of H_2S pollution. — 12. Magyar Elektronmikroszkópos és Mikroanalizis Konferencia előadásainak összefoglalói. Eger, 1982. márc. 29—31. 32. p.

S, A., HORVÁTH, I. and VARGA, J. (1982): A sejtorganellumok szerkezete halak elő- és ősveséjében. — Cytoplasmic organelles in pro- and mesonephros in fishes. — 12. Magyar Elektronmikor. és Mikroanal. Konf. előadásainak összefogl. Eger, 1982. márc. 29—31.

S, A. and MALIK, E. (1983): Change of the contruction of blood cells in the fishes of Tisza. — Comittee Tisza-Research Conference, 12. — Tiscia, *18*, 144. p.

S, A. and HORVÁTH, I. (1983): Changes in the kidney cytoplasmatic organelles as a result of H_2S pollution. — Mikroskopie, Georg Fromme, Wien und München *40*, (3—4), 109.

S, A., HORVÁTH, I. and VARGA, J. (1983): Cytoplasmatic organelles in pro- and mesonephros in fishes. — Mikroskopie, Georg Fromme, Wien und München *40*. (3—4), 124.

ACTA BIOL. SZEGED. 34. PP. 9—10 (1988)

IN MEMORIAM DR. DÁNIEL GÁL
(1934—1988)

Death came to him so dramatically, and unexpectedly. He was only 53.

Born in Lajosmizse in 1934, he attended József Katona Grammar School in Kecskemét. From 1953 he read biology and chemistry at the University of Szeged, graduating in 1957 with distinction.

He began his career as a teacher and research worker at the Department of General Physiology and Biology of this university, and continued this work as a research assistant at the Zoological Department.

His research field was the study of the Tisza fauna, with special focus on the invertebrates. Research meant a great deal to him: a way of living that determined his life. He was dedicated to his work, with unremitting enthusiasm, even during the spring of this year. He published numerous papers on his field, mainly in the journal 'Tiscia'. He delivered lectures at a great number of conferences, the last occasion being in Novi Sad, where his scientific results were received with acclaim. He was awarded his doctoral degree "summa cum laude" in 1966. He was profoundly familiar with the living and dead Tisza areas; he was a perfectionist in his scientific surveying and charting tasks. His contribution to this field is inestimable; without his work our knowledge of the history of the Tisza area would be very much poorer.

Nevertheless, he preferred to be considered a teacher: he could orient and instruct with confidence both in laboratory classes and in field practicals. He sparred no effort to pass on his knowledgee to the younger generation, and he was empathic when it came to examinations.

He was always ready to help his colleagues, whether it was the Department Library or the Collection that needed extra work, or one of us had to be substituted.

At first we hardly even noticed that he was ill. After the medical examinations and an operation, he returned to be among us again as if nothing had happened.

And then came the time when we could not help noticing - to our great despair - that his physical strength and energy were failing him, but we still did not suspect that the disease would end his life so tragically soon.

We all accompanied him on his last journey and we shall all preserve his work and cherish his memory with love and reverence.

Dr. I. Benedeczky

ACTA BIOL. SZEGED. 34. PP. 11—25 (1988)

THE PROLINE TEST — A METHOD TO THE DEMONSTRATION OF THE TOLERANCE OF WATERDEFICIENCY AND OF FROST — AND TO THE QUALIFICATION OF POLLENS

G. PÁLFI[1], S. GULYÁS[2], E.S. RAJKI[3] AND L. CSEUZ[3]

[1]*Department of Plant Physiology and* [2]*Department of Botany, Attila József University, H-6701, Szeged, P.O.B. 654, Hungary*
[3]*Cereal Research Institute, H—6701, Szeged, P.O.B. 391, Hungary*

(Received: December 15, 1987)

Abstract

Based on the proline test a new method was developed by authors for the investigation of drought resistance and frost tolerance of herbaceous cultivated plants and for the estimation of the quality of their pollens. It was established that among the selected varieties of a cultivated plant the drought resistance is higher in these varieties which accumulate more free proline in their isolated leaves exposed to lethal water deficiency (live-wilting) in light during 3 days. The proline test was performed and the grade of drought tolerance was estimated on 7 sorghum hybrids, 3 maize hybrids and on 2 wheat varieties. In frost the cells of the leaves loose very much water and similarly to the soil dryness a significant water deficiency emerges. To protect themselves against this water deficiency the leaves accumulate large quantity of proline. Drought resistance is estimated in the blooming phase while the frost tolerance is investigated on young, 2—4 weeks old shoots. Ripe Pollens of many plants have extremely high (2.0 per cent) proline concentration. The quality of these pollens is proportional with their proline content. Authors' new isatin reagent colours the pollen grains deep blue or black when their proline content is high (these pollens have a very high quality). Most cultivated plants accumulate, high quantity of proline (pollens of "proline type"): the fruit trees of the *Rosaceae* family, the fodder and food plants of the *Papilionaceae*, the cultivated species of the *Solanaceae*, our most important timber woods, and naturally, our cereals.
Key words: mezophyta, families, species, varieties, stress-amino acid = proline

Introduction

A number of authors published that high water deficiency induces accumulation of free proline in the leaves and shoots of herbaceous plants and this significant physiological advantages are assured (TYMMS and GAFF, 1979; CHAUHAN et al., 1980; LEVITT, 1980; TYANKOVA, 1980; PALEG and ASPINALL, 1981).

In different species different quantities of proline accumulate in consequence of gradually obtained and similarly high water deficiency. From the level of proline accumulation no conclusion can be drown to the drought resistance of species (SINGH et al., 1972; PÁLFI et al., 1974; 1975; WALDREN and TEARE, 1974). However, inside a species those varieties, inbred lines and their hybrids are the more drought resistant in which more proline accumulates as the result of a lethal water deficiency. According to VAN DE DIJK (1981) the same level of "outer deficiency" (soil dryness) produces different level of "inner water deficiency" in different

varieties of the same species. This source of error can be eliminated through the equally gradual approach of water deficiency (PINTÉR et al., 1978, 1979; PÁLFI and PINTÉR, 1980; PÁLFI et al., 1983). Investigating 46 species (PÁLFI et al., 1975) it was established that the determination of drought tolerance by proline test can be performed not only on intact plants grown in the field but also on isolated herbaceous shoots and on isolated leaves in 3—4 days (PÁLFY et al., 1974, 1975). During the gradually obtaining of water deficiency ("live-wilting") it is necessary to apply artificial illumination, and adequate temperature and relative humidity as in the case of isolated shoots of alfalfa, clover, wheat or in the case of isolated leaves of maize, tobacco and paprika (PÁLFI et al., 1978; PINTÉR et al., 1979; PÁLFI and PINTÉR, 1980; PÁLFI et al., 1983). By these investigations it was also established that the collection of leaves is the more advisable at blooming time because in this phase accumulate the largest quantity of proline and so — higher degrees of difference among the varieties can be obtained. According to several authors the cold resistance of the plants is realised through diffusion of water from the cells into the intercellulars and departure from there by transpiration through the cuticules. If water frozes inside the cells, the ice crystals disrupt the finer structures, the organells and membranes; this is the frost-killing (HEBER et al., 1971; DRAPER, 1972; THEBUD and SANTARIUS, 1981).

PAQUIN and PELLETIER (1981), PERUANSKIY and STACHENKO (1981) published that among varieties (e.g. selected varieties of autumnal wheat or rye) the most resistant is that which endures better a strong water deficiency, i.e. which accumulates more proline. During repetition of minor cooling and frost, the plants become hardened to frost. Moreover it is well known that in the case of autumnal cereals the several weeks long cold and frost (Yarovization) is absolutely necessary for crop production.

SIMINOVITCH and CLOUTIER (1981) demonstrated on autumnal rye that the variety which has higher drought tolerance, i.e. accumulates more proline, endures better strong frosts.

Sometimes at the blooming time of the cereals and fruit — trees occure dryness in soil or hot spells and also low humidity in the air, and cold snaps with frost as well. Plants accumulate high quantity of proline as a defence againts these extremities of climate. Similarly the pollens of the cultivated plants accumulate much proline even at favourable weather conditions (TUPY, 1963; STANLEY and LINSKENS, 1974; BRITIKOV, 1975).

DASHEK and HARWOOD (1974), ALARKON et al.(1978), KURSAKOV and RYZHKOV (1980), ZHANG et al. (1982) demonstrated that during the germination of the pollen grains the high proline content defends them against unfavourable weather and therefore proline concentration in the pollens is taken as a quality indicator.

Materials and methods

The most important test of drought resistance is the "livewilting", i.e. gradually realized lethal water deficiency in the isolated leaves. In the case of wheat, maize and sorghum leaves collected at blooming time from the same level of the shoots — were spreading on filter paper and fixed by cell tapes at the two end and covered air tight with colourless transparent plastic sheets. They were incubated for 3—4 days in a climate chamber or on a stand at constant illumination of 5000 lux. Under the cover a temperature of 24—28 °C was maintained. In the first 24 hours the relative humidity was 90 per cent, on the second day it was reduced to 80 per cent and on the third day to 60 per cent. Twice in a day the setting up was ventilated for 15 minutes by opening the plastic cover. In the last 12 hours the lethal water deficiency in the leaves must be attained in each varieties (this means an equal level of "inner waterdeficiency"). (Fig. 1—4).

Immediately after the live-wilting process all plant organs were chopped, fixed at 90 °C and desiccated for 8 hours (air dry material). The material was then pulverized in an electric desintegrator and closed in airtight dark containers till performing the analyses.

For determination of cold resistance and frost tolerance the 2—4 weeks old bean, paprika, wheat and rye plants grown in cultivating pots were exposed to 0 °C or -2 °C for 3—4 days. Thereafter the shoots were cut up, fixed, dryed and pulverized and their proline content was determined. The variety which accumulates more proline, is the more frost resistant one (CLOUTIER and SIMINOVITCH, 1981; PAQUIN and PELLETIER, 1981; PERUANSKIY and STACHENKO, 1981).

An other frost resistance test was performed as well. Young shoots grown at optimal conditions were cut off and incubated at a low temperature, required by the variety for 2—4 days under illumination. The proline content of the fixed and dryed shoots was determined (PÁLFI and GULYÁS, 1986).

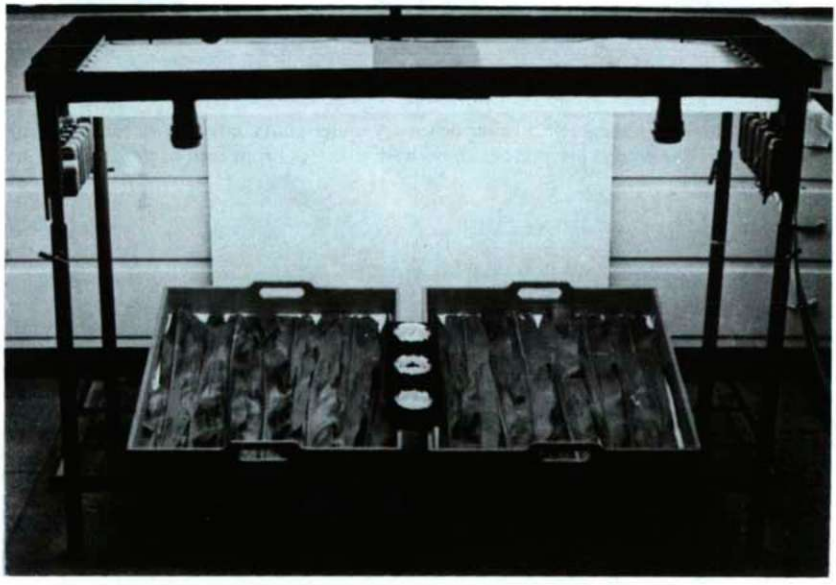


Fig. 1. Gradually obtained lethal water deficiency (livewilting) for 3 days in isolated leaves of 16 inbred maize varieties. The leaves were isolated at he blooming phase and put on plates covered with transparent plastic sheets. They were illuminated with 5000 lux at 24—28 °C at 90 per cent relative humidity which was later reduced to 80 per cent and at last to 60 per cent.

CLOUTIER and SIMINOVITCH (1982) in 9 sorts of autumnal wheat attained by a desiccation stress of young plants the same grade of frost tolerance than by cold hardening at +2 °C for 4 weeks. Autors of this paper (1981) established besides in wheat also in rye that the proline levels in young shoots provoked by live-wilting are indicators of frost tolerance as well.

For determination of proline, the method of ASPINALL et al. (1973) and of BATES et al. (1973) can be used.

The simple and exact new method of proline determination elaborated by the authors of this paper is as follows:

Two hundred mg of the pulverized airdry plant material was mixed with 1 g quartz sand and extracted three times with altogether 20 ml ethanol of 30 per cent concentration each time the mixtures being centrifuged and the supernatants decanted and united forming the amino acid extract. From this 0.05 or 0.10 ml was put on in small portions on the start line on the chromatographic paper from a

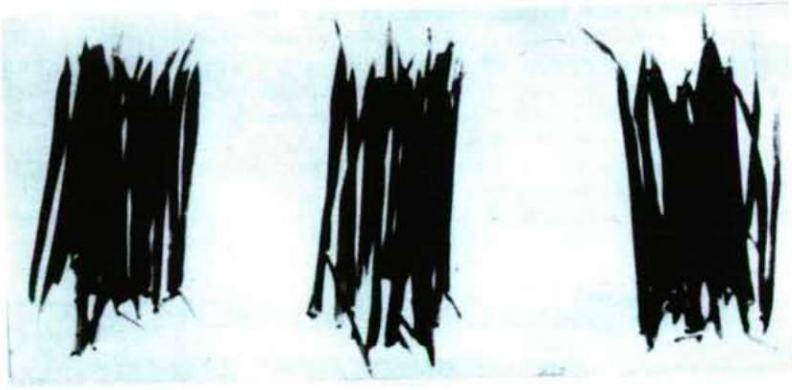


Fig. 2. Gradually obtained lethal water deficiency under plastic cover in wheat leaves isolated at the blooming period. The second leaves from above were isolated. From each of the 3 wheat varieties 20 leaves were taken.

Fig. 3. Provocation of water deficiency in isolated budding alfalfa shoots by mannitol solution of high osmotic pressure. The pot at the left contains water (control). The following pots contain gradually hightening mannitol solutions: 0.4 M; 0.6 M; and 0.8 M respectively. It can be seen thet by increasing the mannitol concentration the shoots are wilting accordingly.

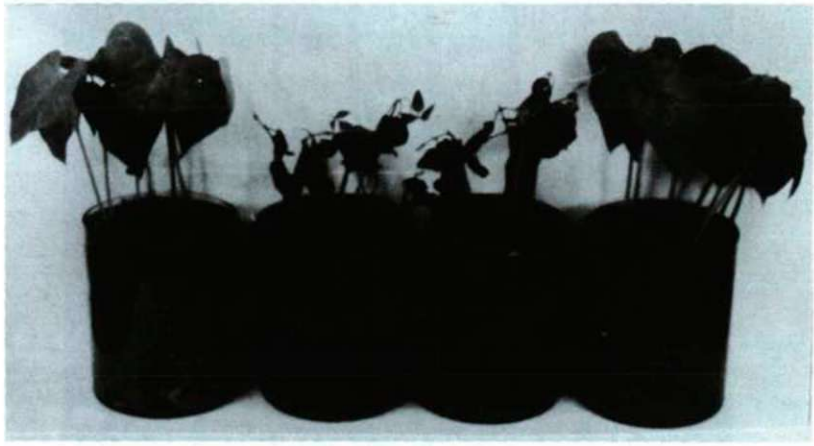


Fig. 4. High water deficiency provoked by "chilled medium" in young bean plants. The water content in the soil of the pots was optimal (70 per cent of the water capacity). The first and the last pots were incubated at 20 °C for 3 days while the two in the centre at 0 °C respectively. The cold stress resulted in heavy wilting.

micropipette and the spots dryed with hot air stream. Each extract was applied three times side by side (3 replications). On the same paper the concentration series of proline standard was applied in 7 stripes (2, 4, 6, 8, 10, 12, and 14 μg from a solution of 1 μg in 0.01 ml). (μg = microgramme).

For one-dimensional developing a phenol-water mixture (4:1 vol.) was used. One night (16—18 hours) is enough for developing (Fig. 5.). The developed paper was taken out and dryed in warm air stream. The dryed paper was immerged into the isatin reagent or drawn 5—6 times through it. Placing the immerged paper on double layer of filter paper it was put in a 90 °C warm exsiccator for 20 minutes; during this time the colours were developed. (Composition of the isatin reagent: to 200 ml acetone 5 ml concentrated acetic acid and 2 g isatin is added). From the paper the superfluous yellow isatin was washed out in running tap water (12—15 minutes) and the paper was blotted between filter papers. Proline has the highest Rf value, it appears as well separated deed blue spot at the top of the paper. The blue spots were cut out with scissors, cut up into small pieces and eluted in a 25 ml Erlenmeyer flask with 5.0 ml mixture of phenol-water (4:1). The flasks put on a plate were incubated in the dark for 15—20 minutes meanwhile they were shaken 4—5 times together with the plate. When the solution is blue and the paper stripes are coulourless, the light absorption was determined at 620 nm in cuvettes of 1 cm in diameter.

From the extinctions of the proline standards a graph was designed from which the proline concentrations of the amino acid extracts can be read off. Thereafter the 0.05 or 0.10 ml developed extract is converted into 18 ml (this quantity remained from the original 20 ml solvent). The obtained value refers to 200 mg dry material. If this value is multiplied by 5 and divided by 1000 the result is expressed in mg proline in 1 g dry material.

In the case of two-dimensional paperchromatography in the first dimension with buthanol-acetic acid-water (3:1:1) is developed at -4 °C — -6 °C. The solvent for the second dimension is phenol-water (4:1), this development is performed at room temperature. The amino acid spots are detected with ninhydrinereagent and fixed with a copper solution.) (Ninhydrine reagent: to 192 ml aceton 1.0 ml concentrated acetic acid, 7 ml distilled water and 1.0 g ninhydrine were added. The paper should be immerged 3—4 times. Copper solution for fixation: to 80 ml methanol and 120 ml isopropanol, 0.8 ml 10 per cent nitric acid and 4.0 ml saturated solution of copper nitrate were added. This is a solution for immersion).

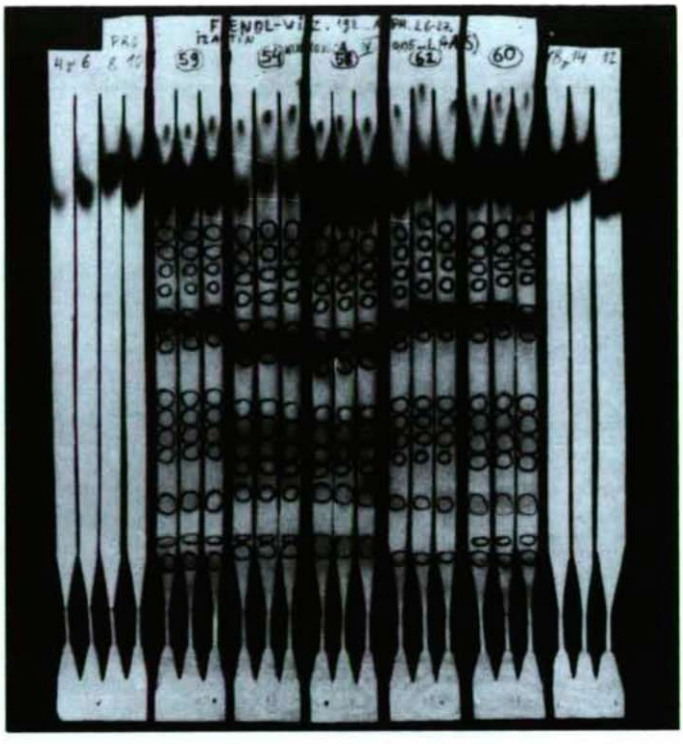


Fig. 5. Unidimensional ascending paper chromatogram of amino acid extracts of inbred maize lines. The five inbred lines show total different proline storages by similar live-wilting. The largest spots on the figure above are that of proline. Each extract developed in 3 parallels. The proline standards can be seen on the outer stripes. The stripes are 1 cm wide while the chromatogram paper is 30 cm high.

From the anemogameous plants (maize and rye) a large quantity of ripe pollens can be collected in a short time. In the case of this species the proline content of the pollens can be determined with the method described above starting from 50, 100 or 200 mg at 90 °C fixed and then dryed and homogenized material. In the autogameous and entomogameous species only small quantities of ripe pollens can be obtained at one occasion. For these plants a new staining method was elaborated with the aid of which the proline concentration in the pollen grains can be estimated on the basis of the colour of the pollen. The staining reagent used is: 20 ml acetone containing 0.4 ml acetic acid and 0.2 g isatin. The staining is performed on the slides-placed pollens. They were mixed with 3—4 drops of the reagent for 5—6 minutes, the colour thereafter was developed at 90 °C for 20 minutes. The preparate was covered with paraffin oil. Detailed description of the method was published elsewhere (PÁLFI and KÖVES, 1984; PÁLFI and GULYÁS, 1985; GULYÁS and PÁLFI 1986; PÁLFI et al., 1987).

Results and discussion

On the two-dimensional paperchromatograms treated with ninhydrine proline shows a relatively weak yellow colour while the other amino acids show intensive purple, blue, violet, brownish or greyish colours (Fig.6.). Fixed with the copper solution nearly all amino acids become red and the colour of proline and asparagine fades out.

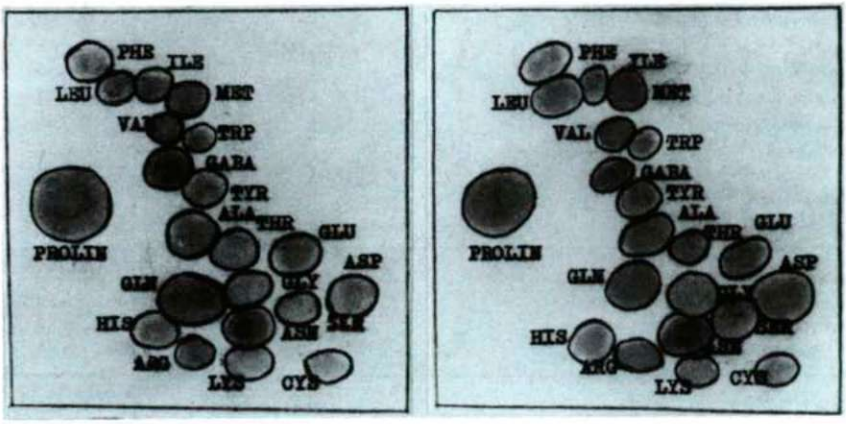


Fig. 6. Twodimensional ascending paper chromatograms of amino acid extracts from wheat and rye leaves. To lethal water deficiency exposed isolated wheat leaves (on the left) and rye leaves (on the right) show significantly higher amino acid content but the largest spot belongs to proline.

On Figure 6. not only the proline spots of the extracts of live-wilted wheat and rye leaves are considerably large but also the other amino acids show relatively large and intensive spots. In the isolated, live-wilted leaves lethal water deficiency induces the accumulation most of the amino acids as well. Intensive accumulation of amino acids, especially that of the amino acid amides occur not only as a result of water deficiency but also as the consequence of one-sided overfeeding with nitrogen or phosphorus or potassium — or the consequence of the absence of a nutritive or of an infectious plant disease. A general accumulation of the amino acids is not specific for water deficiency. The exceedingly high accumulation of proline is absolutely characteristic of water deficiency (PÁLFI and JUHÁSZ, 1971; SINGH et al. 1972; ASPINALL et al., 1973; PÁLFI et al., 1974, 1975; LEVITT, 1980).

Proline concentrations in the leaves of sorghum and maize hybrids and wheat varieties after induced lethal water deficiency (i.e. live-wilting) are seen in Table 1.

Table 1. shows that the levels of proline synthesis and accumulation in the hybrids and varieties of the same species are not the same and sometimes are very different even in the same growing period, in the same level of leaves and even when

Table 1. Proline concentration in isolated leaves of sorghum and maize hybrids and wheat varieties after 3 days long wilting at illumination leading to lethal water deficiency. The leaves were collected in blooming phase. The proline concentration of the non live-wilted and with water optimally supplied leaves never exceeded 0.3 per cent of the dry material.

No.	Species, hybrids and varieties	Proline concentration of the extracts	
		in mg/l g dry matter	per cent of the dry matter
	Sorgum vulgare PERS. hybrids		
1.	Napsugár	5.52	0.55
2.	Remény	5.70	0.57
3.	NK x 7902	4.83	0.48
4.	Alföldi — 1	5.08	0.51
5.	NK x 3221	3.87	0.39
6.	Hybar — 456	3.58	0.36
7.	GKI — 1	4.46	0.45
	Zea mays L. hybrids		
1.	SzeTC 255	2.17	0.22
2.	SzeMSC 267	3.92	0.39
3.	KSC 360	3.24	0.32
	Triticum aestivum, varieties		
1.	Lonja	14.68	1.47
2.	Gk Ságvári	19. 25	1.92

(Average deviation being below ± 5 per cent; n = 3)

the same method was applied for the induction of water deficiency. Among the sorghum hybrids the highest proline concentration was 59.2 per cent larger than that of the smallest one. Among the maize hybrids this difference is higher: 80.6 per cent. The difference in this respect between the two wheat varieties is 31.1 per cent. According to the proline concentration data in Table 1. the investigated hybrids and varieties can be arranged in a series of drought tolerance grades.

Authors investigated with the proline test 23 inbred maize lines. Four of them was found exceedingly drought tolerant (PINTÉR et al., 1978, 1979; PÁLFI and PINTÉR, 1980; PÁLFI et al., 1983). Crossing two such inbred maize lines hybrids with a higher drought tolerance than known up to now could be obtained.

The inbred maize line which accumulates the highest amount of proline concentration during live-wilting produce low yield. But it has an inbred relative with high yield and low drought tolerance. Crossing the two related lines, 64 individuals of the descendants were investigated. The grains of the 5 individuals showing the highest proline concentration during live-wilting were sown next year and 64 individuals were again investigated.

Evaluated statistically the results, it can be established that in the second year the proline content of the leaves and the grade of drought resistance were significantly higher.

Individuals were found the leaves of which contained 7.0 mg proline in 1 g dry material at lethal water deficiency provoked by live-wilting. Such a high value in maize never have been found before (PINTÉR et al., 1978, 1979; PÁLFI and PINTÉR, 1980; PÁLFI et al., 1983).

Cold and frost tolerance

Detetmination of frost tolerance is different from the determination of drought tolerance because in the former case not isolated leaves of adult plants were investigated but young shoots of 2—4 weeks old. Proline accumulation in wheat, rye bean and paprika varieties in consequence of cold is evaluated in Table 2.

It can be seen in Table 2. that the free proline content of the shoots is very low and the differences between the varieties and hybrids are not significant. This proline content can be risen 8—18 times (800—1800 per cent) as a result of cold or frost.

It is interesting that the cold induced proline concentration increases is significantly different between the two varieties of the investigated species. The difference is 35.5 per cent at the wheat, 40.7 per cent at the rye, 33.8 per cent at the bean and 36.2 per cent at the paprika. With these values the colt and frost tolerance of the varieties can be well characterized.

CLOUTIER and SIMINOVITCH (1981) established significant differences between young wheat and rye plants at frost. According to them the increase of proline content is direct proportional to the grade of frost tolerance.

PERUANSKIY and STACENKO (1981) demonstrated also significant differences between frozen young wheat shoots of different varieties. PAQUIN and PELLETIER (1981) established that the proline level in the leaves and roots of wheat varieties increase with their frost tolerance — but only till the falling of the leaves. The higher the frost tolerance the greater is the proline accumulation.

This shows also that photosynthesis has some significance in the formation of frost tolerance.

VAN SWAAIJ et al. (1985) demonstrated on ten potato varieties that the grade of cold tolerance is higher in varieties which accumulate higher quantity of proline caused by cold. They proved also that through externally given proline — the proline content of the shoots can be increased and with this the grade of cold tolerance as well.

YOU-LIANG and STEFONKUS (1983) observed on protoplasts isolated from rye leaves that proline influences the behaviour of non-acclimatized protoplasts. This proves — partly at least — the role of proline in the defence against cold.

According to the above mentioned facts it can be determined with the aid of

Table 2. Proline accumulation in young shoots of two varieties of wheat, rye, bean and paprika, provoked by chilling at —2 °C and 0 °C for 3 days at illumination.

Species, varieties	Temperature of the soil	Proline concentration, in mg/l g dry matter
Triticum aestivum L. varieties		
Lonja	20 C°	0.34
GK Ságvári	20 C°	0.33
Lonja	–2 C°	4.11
GK Ságvári	–2 C°	5.57
Secale cereale L. varieties		
Lovászpatonai	20 C°	0.43
Verhnigskaja	20 C°	0.42
Lovászpatonai	–2 C°	4.08
Verhnigskaja	–2 C°	5.74
Phaseolus vulgaris L. varieties		
A — 328	20 C°	0.16
B — 432	20 C°	0.15
A — 328	0 C°	2.97
B — 432	0 C°	2.22
Capsicum annuum L. varieties		
A — 38—43	20 C°	0.33
B — 27—57	20 C°	0.37
A — 38—43	0 C°	4.25
B — 27—57	0 C°	3.12

(Average deviation being below ± 5 per cent; n = 3)

proline test which selected variety of plant species has higher cold and frost tolerance.

Proline content can be a quality indicator of pollens in many plants.

Investigating the isatin stained pollens in light microscope: intensive blue, deep blue and black pollen grains can be seen ("positive reaction with isatin"). These colours appear when proline concentration of the pollens is very high (2 per cent). The high proline content is correlated with high vitality because proline defends the pollens against high temperature and dryness of air as well as against cold and frost

(BRITIKOV, 1975; AHOKAS, 1978; ALARKON et al., 1978; DASHEK and MILLS, 1981; ZHANG and CROES, 1983).

Such high quality pollens appear black on the black and white photos (Fig.7).

The light greenish blue or light blue (transparent) coloured grains has low proline content and this indicates low quality. These colours are not considered as "positive isatin reaction". Many grains retain their original yellow colour in spite of staining with isatin or they show light red or brownish colours. These grains contain proline in traces only, they are of the lowest quality (Fig.7).

In Table 3. the proline concentration and the per cent values of positive isatin staining of the pollens of 36 species belonging to 12 differently developed families are shown.

It can be established that positive isatin reaction grows proportionally (from 32 to 92 per cent) to the proline concentration of the pollen extracts. The isatin reagent produces deep blue or black colours only in those grains, which contain high quantity of proline (2.0 per cent).

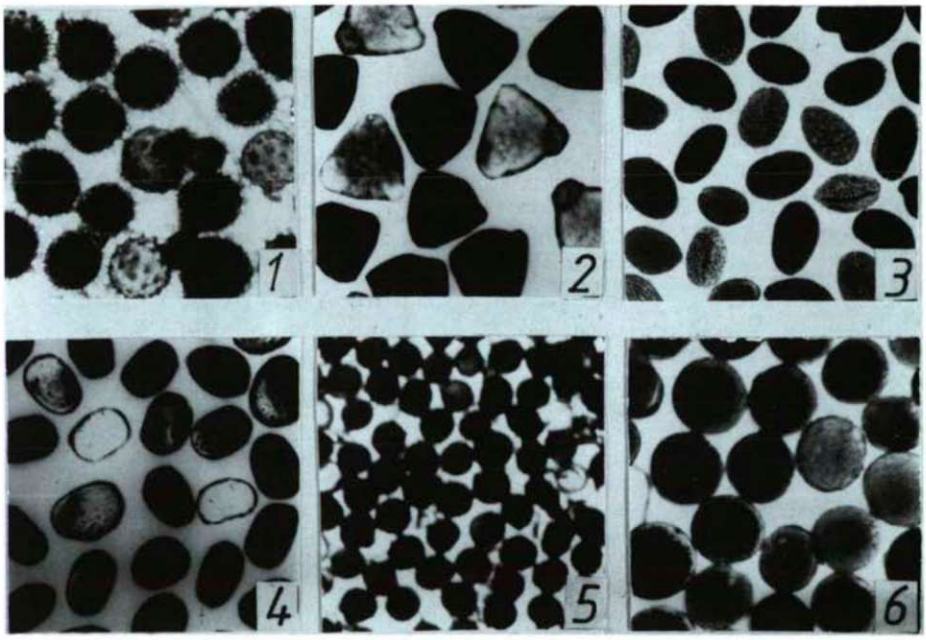


Fig. 7. Estimation of the quality of pollen grains with isatin reagent. The proline content of the deep blue and black coloured (on the picture all black) pollen grains is very high: these are pollens of excellent quality. The pollen grains coloured yellow, light brown and greenish (on the pictures grey) contain few proline, therefore they represent lower quality.

Magnified: 100—400 times.

1 = *Hibiscus rosa sinensis*; 2 = *Persica vulgaris*; 3 = *Lilium candidum*;
4 = *Secale cereale*; 5 = *Triticum aestivum*; 6 = *Zea mays*.

Table 3. Proline concentration in the dry material of the pollens and the percentage of isatin positive grains (5x100 grains were counted) of 36 monocotyledonous and dicotyledonous species. Isatine positive are the grains coloured deep blue or black. The species belong to 12 families; among them there are autogameous, anemogameous, and entomogameous too.

Families	Species	Proline concentration of the extracts	Positive reaction with isatin
		per cent	
Rosaceae	1. *Armeniaca vulgaris*	1.37	53
	2. *Pyrus communis*	1.28	44
	3. *Malus pumila*	1.39	54
	4. *Cerasus vulgaris*	1.43	57
	5. *Persica vulgaris*	1.45	55
	6. *Prunus domestica*	1.66	64
Fabaceae	7. *Trifoliun repens*	1.35	51
	8. *Medicago sativa*	1.34	50
	9. *Robinia hispida*	1.38	53
	10. *Vicia faba*	1.32	47
	11. *Pisum sativum*	1.54	61
	12. *Phaseolus vulgaris*	1.33	50
Solanaceae	13. *Solanum tuberosum*	1.38	54
	14. *S. melongena*	1.52	62
	15. *Capsicum annuum*	1.60	64
	16. *Lycopersicon escul.*	1.37	57
	17. *Nicotiana tabacum*	1.42	56
Papaveraceae	18. *Papaver somniferum*	1.45	57
Cucurbitaceae	19. *Cucumis sativus*	1.53	63
Compositae	20. *Dahlia variabilis*	1.36	52
Betulaceae	21. *Betula pendula*	1.16	35
	22. *Corylus avellana*	2.20	92
Fagaceae	23. *Fagus silvatica*	1.63	66
	24. *Quercus robur*	1.56	61
Juglandaceae	25. *Juglans regia*	1.15	32
Salicaceae	26. *Salix cinerea*	1.62	66
	27. *Populus alba*	1.25	45
Liliaceae	28. *Lilium candidum*	1.18	39
	29. *Allium cepa*	1.76	77
Gramineae	30. *Lolium perenne*	1.84	80
	31. *Secale cereale*	1.32	47
	32. *Triticum eastivum*	1.53	64
	33. *Hordeum vulgare*	1.45	56
	34. *Sorgum vulgare*	1.71	73
	35. *Zea mays*	2.22	91
	36. *Oryza sativa*	1.63	65

(Average deviation being below ±5 and ±9 %; n=3 and 8)

The grains with positive isatin reaction represent the highest quality as already is described by several authors (TUPY, 1963; STANLEY and LINSKENS, 1974; BRITIKOV, 1975; ALARKON et al., 1978; DASHEK and MILLS, 1981).

KURSAKOV and RYZHKOV, 1980, ZHANG and CROES (1983) and PÁLFI and KÖVES (1984) demonstrated that germination of pollens and elongation of their tubes in agar medium can be increased by 50 per cent by externally added proline.

According to these authors high concentration of proline stabilizes water economy and respiration, promotes germination and the elongation of tube and has a role in the synthesis of the proteins of the tube wall. Proline is at the same time the protein amino acid which has the highest solubility in water and it is not toxic to the plants even in high concentration (PÁLFI and KÖVES,1984). At the same time proline is the most stabile amino acid as well (PÁLFI and GULYÁS, 1985; GULYÁS and PÁLFI 1986).

Investigating many families it was established, however, that not every plant species has pollens with high quantity of proline; in spite of their excellent germination they contain only 0.10 — 0.25 per cent proline. These pollens are named as "non-proline-type".

Such non proline type pollens has *Coronilla varia, Brassica napus, Begonia semperflorens, Cucurbita pepo, C. maxima, Helianthus annuus, Dactylis glomerata, Bromus inermis, Poa pratensis, Holcus lanatus, Festuca pratensis* and *F. vaginata.*

Ripe pollens of most of the important cultivated plants react positive with isatin reagent due to their high proline content, they are of the "proline type". To this type belong all fruit-trees of the *Rosaceae* family (Table 3.), the most important food and forage plants of the *Papilionaceae*, the food species of the *Solanaceae*, our timber woods and all the cereals.

In plant breeding the crossing of varieties having pollens of high proline content, new varieties can be obtained which has pollens with significantly higher proline content. Several authors suppose that ability to proline accumulation is a hereditary character (BRITIKOV, 1975; AHOKAS, 1978; ALARKON et al., 1978).

Authors of this paper established also that in inflorescences (e.g. spike, panicle, calathium) ripening of the pollens begins at the different parts of the inflorescence and at the first place of dispersion are produced the grains of best quality (PÁLFI et al., 1987).

In the spikes of wheat, barley and rye the ripening of the pollens begins in the middle, in maize and rice on the upper parts of the panicle and at *Compositae* on the outher circles of the calathium. It is therefore important that comparing pollens the samples were taken from the same parts of the inflorescence.

Proline has the most important role in the defense against water deficiency and frost. Proline has the same function also in influencing the quality of pollens.

Proline can be named therefore as a "stress amino acid".

References

AHOKAS, H. (1978): Cytoplasmic male sterility of barley. II. Physiology and anther cytology of msml. — Hereditas. *89*, 1—21.

ALARKON, N.A., LARIONOVA, E.G. and MININA, T.K. (1978): Amino acids of pollen *Pinus sibirica*. — Fiziol. Rastenij. *26*, 186—189.

ASPINALL, D., SINGH, T.N. and PALEG L.G. (1973): Stress metabolism. V. Abscisic acid and nitrogen metabolism in barley and *Lolium temulentum* L. — Austral. J. Biol. Sci. *26*, 319—327.

BATES, L.S., WALDREN, R.P. and TEARE, I.D. (1973): Rapid determination of free proline for water stress studies. — Plant and Soil. *39*, 205—207.

BLUM, A. and EBERCON, A. (1976): Genotyp responses in sorghum to drought stress. III. Free proline accumulation and drought resistance. — Crop. Sci. Madison. 16, 428—431.

BRITIKOV, E.A. (1975): Biologicheskaya roly prolina. Izd. Nauka. Moskow.

CHAUHAN, R.P.S., CHAUHAN, C.P.S. and KUMAR, D. (1980): Free proline accumulation in cereale in relation to salt tolerance. — Plant and Soil. *57*, 167—175.

CLOUTIER, Y and SIMINOVITCH, D. (1981): Correlation between cold and drought-induced frost-hardiness in wheat and rye varieties. — Plant. Physiol. *67*, (Suppl. No. 4.) 62. 346.

CLOUTIER, Y. and SIMINOVITCH, D. (1982): Augmentation of protoplasma in drought- and cold-hardened winter wheath. — Can. J. Bot. *60*, 674—680.

DASHEK, W.V. and HARWOOD, H.I. (1974): Proline, hydroxyproline and lily pollen tube elongation. — Ann. Bot. *38*, 947—959.

DASHEK, W.V. and MILLS, R.R (1981): Proline metabolism by germinating *Lilium longiflorum*. — Acta, Soc. Pol. Bot. *50*, 51—66.

GULYÁS, S. and PÁLFI, G. (1986): Proline-type pollens and their vitality in the *Rosaceae* and the species of other families. — Acta Biol. Szeged, *32*, 9—18.

HEBER, U., TYANKOVA, L. and SANTARIUS, K. (1971): Stabilization and inactivation of biological membranes during freezing in the presence of amino acids. — Biochem. Biophys. Acta. *241*, 578—592.

KURSAKOV, A.G. and RYZHKOV, S.D. (1980): The content of free amino acids in oppositely charged fractions of black-currant pollen. — Fiziol. Rastenij. *27*, 735—739.

LEVITT, J. (1980): Responses of plants to environmental stresses. Vol. II. Water, radiation, salt and other stresses. — Academic Press. New York — London.

MALI, P.C. and MEHTA, S.L. (1977): Effect of drought on enzimes and free proline in rice varieties. — Phytochem. *16*, 1355—1357.

PALEG, G. and ASPINALL, D. (1981): Water stress in plants. — Acad. Press. New York.

PAQUIN, R. and PELLETIER, G. (1981): Acclimation naturelle de la luzerne (*Medicago media* PERS.) au froid 1. Variations de la teneur en proline libre des feuilles et des collets. — Physiol. Veg. Paris. *19*, 103—117.

PÁLFI, G. and GULYÁS, S (1985): Complementary data to the viability test of pollens. — (Adatok a pollenek vitalitás vizsgálatának a kiegészítéséről). — Növénytermelés. *34*, 351—358.

PÁLFI, G., GULYÁS, S. SZÖLLŐSI, I. and E. SIKLÓSI RAJKI (1987): Sequence of pollen ripening and quality of various parts of inflorescences and method of sampling (A virágzatok különböző részeinek pollenérési sorrendje, minősége és a mintavétel módszere). — Növénytermelés. *36*, 171—182.

PÁLFI, G. and JUHÁSZ, J. (1971): The theoretical basis and practical application of a new method of selection for determining water deficiency in plants. — Plant and Soil. *34*, 503—507.

PÁLFI, G. and KÖVES, E. (1984): Determination of vitality of pollen on the basis of its amino acids content. — Biochem. Physiol. Pflanzen. *179*, 237—240.

PÁLFI, G., KÖVES, E. and BITÓ, M. (1974): The role of amino acids during water stress in species accumulating proline. — Fyton. *32*, 121—127.

PÁLFI, G., KÖVES, E. and NEHÉZ, R. (1975): Effect of growth substances on the free amino-acid content of lentil shoots in case of water deficiency. — Acta Biol. Szeged. *21*, 69—82.

PÁLFI, G., NÉMETH, J., PINTÉR, L. and KÁDÁR, K. (1978): Rapid determination of drought-resistance of new rye, maize and lupine varieties with the live-wilting proline test. — Acta Biol. Szeged. *24*, 39—51.

PÁLFI, G. and PÁLFI, Zs. (1982): A rapid method for the determination of fertility of maize pollen with the proline-isatin reaction. — Maydica. *27*, 107—111.

PÁLFI, G., PÁLFI, Zs. and PINTÉR, L. (1983): Enhancement of degree drought-resistance in varieties by crossing and selection on the basis of the proline content. — Acta Biol. Szeged. 29, 11—17.

PÁLFI, G. and PINTÉR, L. (1980): Determination of the drought-resistance of inbred maize lines with proline test. — Acta Biol. Szeged. 26, 109—116.

PERUANSKIY, J.V. and STACHENKO, A.P. (1981): Svobodniy prolin vegetativnih organov — biochimicheskij pokazately morozoustojkosti ozimoy psenici. selyhoz. — Biol. *16*, 740—743.

PINTÉR, L., KÁLMÁN, L. and PÁLFI, G. (1978): Determination of drought resistance in different hybrids of maize by fiel trials and biochemical tests. — Maydica. Bergamo. *23*, 121—127.

PINTÉR, L., KÁLMÁN, L. and PÁLFI, G. (1979): Determination of drought resistance in maize (*Zea mays* L.) by proline test. — Maydica. *24*, 155—159.

SASHIDHAR, V.R., MEKHRI, A.A. and KRISHNASASTRY, K.S. (1977): Proline accumulation in relation to seed hardening in groundnut genotypes. — Indian J. Agric. Sci. *47*, 595—598.

SIMINOVITCH, D. and CLOUTIER, Y. (1981): 24-Hour induction of freezing and drought resistance in plumules of winter rye seedlings by desiccation at room temp. in the dark. — Plant Physiol. 67, (suppl. No 4. 345.) 62.

SINGH, T.N., ASPINALL, D. and PALEG, L.G. (1972): Proline accumulation and varietal adaptability to drought in barley: a potential metabolic measure of drought resistance. — Nature New Biol. *236*, 188—189.

SRINIVASA, V. (1977): Free proline accumulation and reduction in RWC under moisture stress in genotypes of safflower. — Curr. Sci. Bangalore. *46*, 646—647.

STANLEY, R.G. and LINSKENS, H.F. (1974): Pollenbiology, management, biochemystry. Springer Verlag. Berlin-Heidelberg-New York.

THEBUD, R. and SANTARIUS, K.A. (1981): Effects of freezing on isolated plants mitochondria. — Planta. *152*, 242—247.

TUPY, J. (1963): Free amino acids in apple pollen from the point of view of its fertility. — Biol. Plantarum. *5*, 154—159.

TYANKOVA, L. (1980): Soderzhania prolina, svobodnih aminokislot, obschhego i belkovogo azota i sahar kak funkciya prodolzhitelynosti stepeni podsuhaniya otdelennih listyev tabaka. — Fiziol. Restaniy. *27*, 806—813).

TYMMS, M.J. and GAFF, D.F. (1979): Proline accumulation during water stress in resurrection plats. — J. Exp. Bot. *30*, 165—168.

VAN DE DIJK, S.J. (1981): Two ecologically distinct subspecies of *Hypochaeris radicata* L. III. Differences in drought resistance. — Plant and Soil. *63*, 149—163.

VAN SWAAIJ, A.C., JACOBSEN, E. and FEENSTRA, W.J. (1985): Effect of cold hardening, wilting and exogenously applied proline content of frost tolerance of several genotypes of *Solanum*. — Physiol. Plant. *64* 230—236.

WALDREN, R.P. and TEARE, I.D. (1974): Free proline accumulation in drought—stressed plants. — Plant and Soil. *40*, 689—692.

ZHANG, H.Q. and CROES, H.F. (1983): Proline metabolism in pollen : degradation of proline during germination and early tube growth. — Planta. *159*, 46—49.

ZHANG, H.Q., CROES, H.F. and LINSKENS, H.F. (1982): Protein sythesis in germinating pollen of *Petunia*: role of proline. — Planta. *154*. 199—203.

YOU-LIANG and STEPONKUS, P.L. (1983): Influence of proline on the tolerance of isolated protoplasts to osmotically induced contraction (expansion). — Plant Physiol. *72*, (Suppl. No. 1.530) 93.

ACTA BIOL. SZEGED. 34. PP. 27—33 (1988)

CORRELATIONS OF THE QUALITY OF THE POLLEN GRAINS WITH THE TEMPORAL SEQUENCE OF POLLEN DISPERSION IN THE DIFFERENT PARTS OF THE INFLORESCENCES

G. PÁLFI, S. GULYÁS AND E. S. RAJKI*

Department of Plant Physiology and Botany, Attila József University, H—6701, Szeged, P.O.B. 654, Hungary and Cereal Research Institute, Szeged, P.O.B. 391*

(Received: July 28, 1987)

Abstract

Free proline concents of the pollen grains of many species have been determined. The pollen grains are differently stained with isatin-reagent and can be divided into the group with "proline-type" pollen and that with "non-proline-type" pollen, respectively. Differences in quality of the pollen grains from different parts of the calathia, panicles and spikes were demonstrated. Better quality pollen were obtained by the first pollen dispersion of the inflorescences.

It was stated that the comparison of pollen collected only from identical pollination regions of the inflorescences can present characteristic genetic data on the selected varieties belonging to one species.

Key words: Proline in pollens, staining with isatin, families, genera, species, plant breeding.

Introduction

It is already known that the proline content of the pollen of many plants is very high. It can be compared with leaves of plants subjected to water deficiency (DASHEK and HARWOOD 1974; BRITIKOV, 1975; AHOKAS, 1978; etc.). Physiological advantage of proline accumulation is known as well (ALARKON et al., 1978; KURSAKOV and RYZHKOV, 1980; PALEG and ASPINALL, 1981; TYANKOVA et al., 1982; PÁLFI and KÖVES, 1984; GULYÁS and PÁLFI,1986). It was demonstrated that mature pollen grains of many species contain excessively high quantity of proline while in material of some other species this compound can be demonstrated only in a very low concentration (PÁLFI and KÖVES, 1984; PÁLFI and MIHALIK, 1985; PÁLFI and GULYÁS, 1985).

In this work the sequence of pollen dispersal in some inflorescences was studied. It was also investigated whether accumulation of proline is correlated with the mode of pollination. Finally data were collected about connections between the evolution of the families and genera and the measure of proline accumulation.

Materials and Methods

Flowers and pollen collected from the Botanical Garden of the University were fixed and dried at 90 °C.

Isatin-reagent stains the pollen grains with significantly different colours according to proline content (PÁLFI and KÖVES, 1984). The recipe of the reagent: 0.4 ml acetic acid and 0.2 g isatin are added to 20 ml acetone. 2—20 mg pollen grains are mixed with some drops of the reagent on a slide and the staining reaction is performed at 90 °C for 12 minutes. The pollen grains are then dispersed in a drop of paraffin oil and covered. Details of the procedure are published elsewhere (PÁLFI and KÖVES, 1984.). Five microscopic fields each containing 50—100 pollen grains were counted and the per cents of positive isatin reaciton were given as mean values. Proline concentration of pollen estracts was determined by the method of ASPINALL et al. (1973) in three repetitions. The average values were published.

Results and Discussions

Staining-reaction was considered positive (demonstrating a very high proline content) when the pollen grains stained intensive blue, dark blue or black with the isatin reagent. On black and white photos the positively reacting pollen grains are black while negative reaction appears in different shades of grey (Plate 1.).

On Plate 1. the isatin-reaction of 12 species (belonging to 12 families) is seen. By most species black and grey pollen grains occur mixed. High proline content demonstrated by the isatin-reaction occurs in many species.

Maturing dispersion of pollen grains commences in special parts of the inflorescences. According to this sequence mature pollen of different quality can be collected (Table 1.).

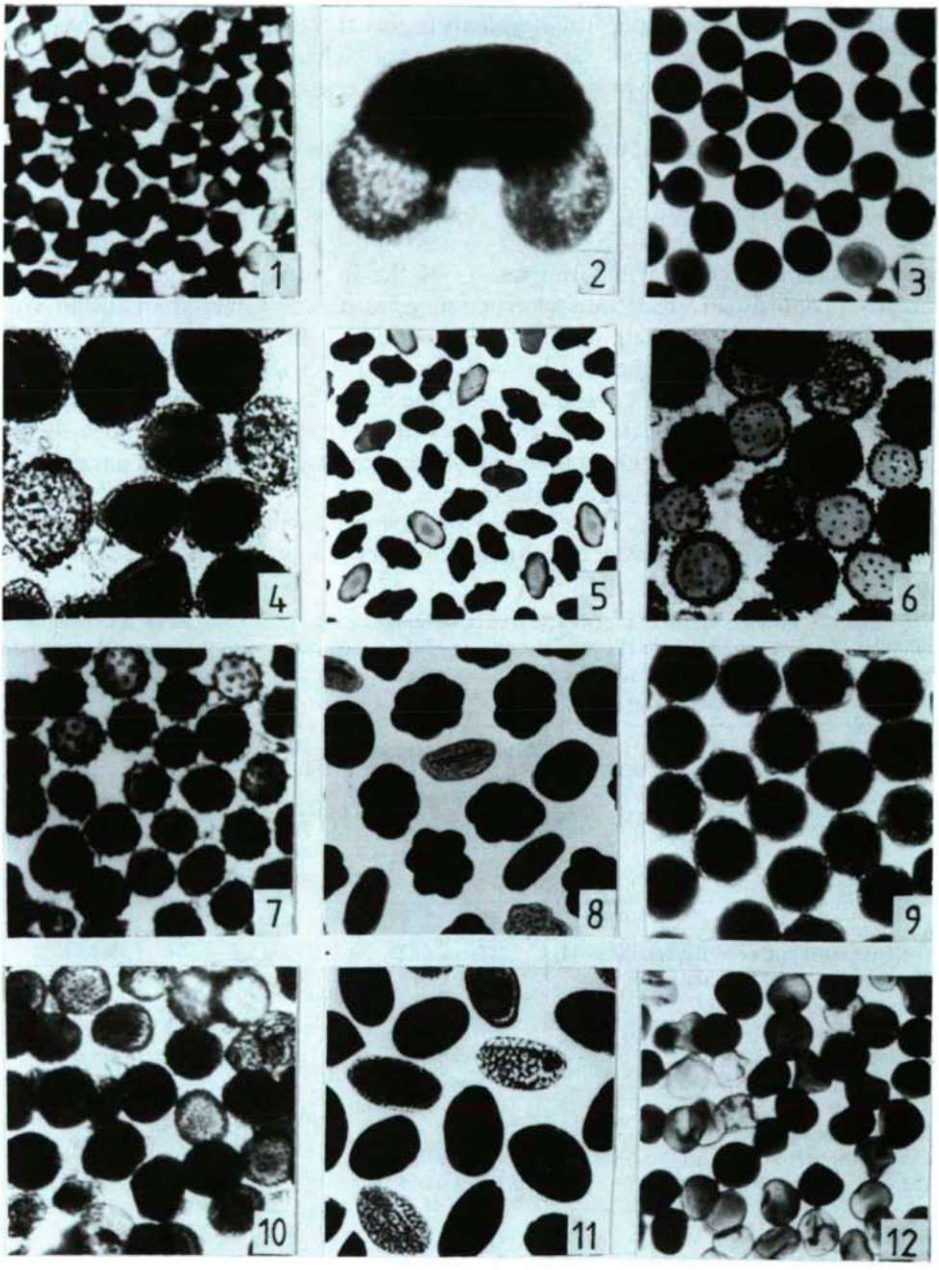
In the case of *Chrysanthemum leucanthemum* the dispersion of the pollens begins at the flowers of the outher circles of the calathium and this part of the inflorescence produces the best pollen quality. Dispersion of pollens advancing centripetally terminates within 3 or 4 days but from the central parts many non-vital grains occur.

Captions

Plate I. Mature and normally developed pollen grains stain black with the isatin-reagent. These are the "isatin positive" or "proline type" grains. The pollen grains stained grey contain very few proline, their maturity and quality is of low degree.

Magnification 200—800 x.

1 = *Ranunculus arvensis*; 2 = *Pinus nigra*; 3 = *Phaseolus vulgaris*; 4 = *Lonicera tatarica*; 5 = *Anthriscus caucalis*; 6 = *Hibiscus rosa-sinensis*; 7 = *Chrysanthemum horturum*; 8 = *Glechoma hederaceum*; 9 = *Opuntia vulg.*; 10 = *Iris germanica*; 11 = *Lilium longiflorum*; 12 = *Triticum aestivum*.


1
2
3
4
5
6
7
8
9
10
11
12

In *Sorgum bicolor* dispersion of pollens begins at the tip of the panicle branches and also in this case the initial parts give pollens of higher quality. After 4—5 days at the lowermost parts of the branches the pollen dispersion terminates, giving pollens of low quality.

In the spikes of wheat and of rye the dispersion of pollen begins at the middle part and here the best pollen quality is found. The dispersion of pollen advances to the basis and apex producing pollen of lower and lower quality.

Data of Table 1. show that proline content of the pollen extracts, the per cent of positive staining reaction and the results of the in vitro pollen germination are directly proportional. The staining reaction gives higher values than the in vitro germination. A positive staining reaction is caused by the proline quantity.

In Table 2. data can be seen from 29 species belonging to families of different stage of evolution. Proline concentration of the pollen extract is very high (1.0—2.3 per cent of dry matter) in the first 18 species (numbered with 1 to 18). Also the per cent positive staining reaction is high (44—85 per cent) and it increases paralell with the proline content of the extracts (as in table 1.).

In Table 2., however, there are 11 other species (numbered again beginning with 1) the pollen extract which contains only very few proline: 6 to 10 times fewer

Table 1. Proline content of the pollen extracts, staining of pollen grains with isatin, and in vitro germination of pollen grains. Correlations of the quality of the pollen grains with the temporal sequence of pollen dispersion in the different parts of the inflorescences.

Names of the species and part of the inflorescence	Proline content of pollen extracts; % of dry matter	Percentage	
		of pollen grains stained black (isatin positiv)	of in vitro germination of pollen grains
Chrysanthemum leucanthemum			
The outermost circles of the calathium (1)	1.71 ± 0.082	68 ± 5.4	64 ± 6.0
The central part of the calathium	1.27 ± 0.058	41 ± 4.0	36 ± 3.7
Sorghum bicolor			
The top of the panicle (1)	2.15 ± 0.102	88 ± 7.1	78 ± 6.8
The lower part of the panicle (2)	1.58 ± 0.073	57 ± 4.5	51 ± 4.6
Triticum vulgare			
The central part of the ear (1)	1.73 ± 0.076	76 ± 5.2	72 ± 6.5
The external part of the ear (2)	1.57 ± 0.065	55 ± 4.3	53 ± 5.0
Secale cereale			
The central part of the ear (1)	1.70 ± 0.081	67 ± 5.8	64 ± 5.9
The external part of the ear (2)	1.19 ± 0.053	38 ± 2.9	35 ± 3.1

(1) = Beginning of the pollination;
(2) = Termination of the pollination.

than in the former group. The staining reaction in these 11 species is negative due to the low proline content.

On the basis of this and previous works (PÁLFI and KÖVES, 1984; PÁLFI and GULYÁS 1985; GULYÁS and PÁLFI, 1986) flowering plants were classified into two types: 1. to the "proline type" belong species in which the proline content of the

Table 2. Due to their extremely high proline content the pollen grains stain black with the isatin reagent (species 1—18); these are the "proline type" species. In the other species mature pollens due to their very low proline content no one grain stains black; these are the "non-proline-type" species (species 1—11).

Families	Species	Proline content of pollen extracts; of dry matter %	Pollen grains stained black (isatin positive) %
Ranunculaceae	1. *Paeonia arborea*	1.28 ± 0.062	45 ± 4.1
Ranunculaceae	2. *P. officinalis*	1.43 + 0.069	53 + 5.2
Fabaceae	3. *Lathyrus tuberosus*	1.56 ± 0.071	59 ± 5.5
Fabaceae	4. *L. sativus*	1.34 ± 0.064	50 ± 4.6
Cucurbitaceae	5. *Cucumis sativus*	1.39 ± 0.060	53 ± 5.0
Solanaceae	6. *Solanum luteum*	1.82 ± 0.083	80 ± 7.7
Solanaceae	7. *S. dulcamara*	1.77 ± 0.081	78 ± 7.1
Solanaceae	8. *S. nigrum*	1.66 ± 0.075	65 ± 5.8
Compositae	9.*Senecio vernalis*	1.49 ± 0.064	57 ± 5.1
Compositae	10. *S. vulgaris*	1.67 ± 0.078	68 ± 5.7
Fagaceae	11. *Qercus robur*	1.26 ± 0.052	44 ± 4.2
Iridaceae	12. *Iris germanica*	1.38 ± 0.062	52 ± 4.5
Iridaceae	13. *I. pumila*	1.25 ± 0.053	44 ± 4.0
Liliaceae	14. *Colchicum autumnale*	2.30 ± 0.110	85 ± 7.6
Graminae	15. *Lolium perenne*	1.46 ± 0.065	54 ± 4.3
Graminae	16. *L. multiflorum*	1.68 ± 0.080	67 ± 6.2
Graminae	17. *Glyceria maxima*	1.50 ± 0.068	58 ± 5.2
Graminae	18. *Hordeum vulgare*	1.91 ± 0.093	84 ± 7.3
Compositae	1. *Helianthus annuus*	0.21 ± 0.010	—
Polygonaceae	2. *Rumex undulatus*	0.22 ± 0.011	—
Polygonaceae	3. *R. crispus*	0.20 ± 0.009	—
Cucurbitaceae	4. *Cucurbita maxima*	0.18 ± 0.009	—
Cucurbitaeae	5. *C. pepo*	0.21 ± 0.009	—
Liliaceae	6. *Tulipa gesneriana*	0.20 ± 0.009	—
Liliaceae	7. *T. germanica*	0.22 ± 0.010	—
Gramineae	8. *Dactylis glomerata*	0.16 ± 0.007	—
Gramineae	9. *Festuca falcata*	0.20 ± 0.009	—
Gramineae	10. *F. pratensis*	0.21 ± 0.008	—
Gramineae	11. *Agropyron repens*	0.22 ± 0.010	—

mature pollen is higher than 1.0 per cent of dry matter. 2. The mature pollen of the "non-proline-type" species contain less than 1.0 per cent proline. In 4 families (*Cucurbitaceae, Compositae,Liliaceae* and *Gramineae*) both the proline-type and non-proline-type species occur. The proline type therefore is not characteristic of a family. All species belonging to the same genus are either of proline-type or of non-proline-type (1. and. 2. *Paeonia*; 3. and 4, *Lathyrus*; 6., 7. and 8. *Solanum*; etc. as well as 2. and 3. *Rumex*; 4. and 5. *Cucurbita*; 6. and 7. *Tulipa*; 9. and 10 *Festuca*).

In Table 2. the families are arranged roughly according to their evolutionary progress. It can be seen that proline-type pollens occur in the families which are primitive (*Ranunculaceae*) moderately developed (*Solanaceae*), more advanced (*Fagaceae*) as well as in the most advanced monocotyledonous families. There is not relation between proline-type and phylogenetic development. In Table 2. entomophilous, anemophilous and autogameous species were compared: the proline-type is not correlated with the mode of pollination.

On examining the pollen quality of selected varieties belonging to one species the comparison of pollen grains collected only from the identical pollination regions of the inflorescences can give reliable genetic data. In all the three kinds of inflorescences studied best quality pollen grains were spread by the first pollen ripening region (calathium, panicle, spikes). Plant breeder experts may come to a conclusion that fertilization with pollen grains from the first pollination regions of the inflorescences ought to provide significant seed vigour, i.e. a considerable biological advantage. It is necessary to study the pollination sequence and quality of a number of plants to benefit from this advantage.

A plant belonging to the "proline-type" group may have a significant role in plant breeding if one takes into consideration that all the most important agricultural species selected long ago do belong to this group: e.g. wheat, maize, barley, rye, rice, potatoes, paprika, lucerne, clover and almost all fruit trees.

References

AHOKAS, H. (1978): Cytoplasmic male sterility of barley.II. Physiology and anther cytology. — Hereditas. *89*, 7—21.

ALARKON, N.A., LARIONOVA, E.G., and MININA, T.K. (1978): Amino acid of pollen of *Pinus sibirica*. — Fiziol. Rastenij. *26*, 186—189.

ASPINALL, D., SINGH, T.N. and PALEG, L.G. (1973): Stress metabolism. V. Abcisic acid and nitrogen metabolism in barley and *Lolium temulentum* L. — Austral. J. biol. Sci. *26*, 319—327.

BRITIKOV, E.A. (1975): Biologicheskaya roly prolina. Izd. "Nauka" Moskow.

DASHEK, W.V. and HARWOOD, H.I. (1974): Proline, hydroxyproline and lily pollen tube elongation. — Ann. Bot. *38*, 947—959.

DASHEK, W.V. and MILLS, R.R. (1980): Azetidin-2-carboxylic acid and lily pollen tube elongation. — Ann. Bot. *45*, 1—12.

GULYÁS, S., and PÁLFI, G. (1986): Determination of pollen fertility in insect-pollinated plant species by a proline-isatin staining method.— Fiziol. Rastenij. *33*, 610—614.

KURSAKOV, A.G. and RYZHKOV, S.D. (1980): Soderjanie svobodnih aminokislot v raznoimenno zaryajennih frakciyah pilyci chernoj smorodini.— Fiziol. Rastenij. *27*, 735—739.

PALEG, L.G. and ASPINALL. D. (1981): The physiology and biochemistry of drought resisitance in plants.— Academic Press. Sydney, New York, London. 206—231.

PÁLFI, G. and GULYÁS, S. (1985): Complementary data to the viability test of pollens. — Növénytermelés (Hung. res. eng.) *34*, 351—358.

PÁLFI, G. and KÖVES, E. (1984): Determination of vitality of pollen on the basis of its amino acid content. — Biochem. Physiol. Pflanzen. *179*, 237—240.

PÁLFI, G. and MIHALIK, E. (1985): Proline staining as a new method for determining the vitality of pollen grains in wind and insect pollinated plants. — Acta Bot. Acad.Sci.Hung. *31*, 315—321.

TYANKOVA, L., TRIFONOV, A. and KUSMANOVA, R. (1985): A spectroscopic (ATR) approach to the behaviour of proline- and sucrose-treated biomembranes towards dehydratation and rewatering. — Biochem. Physiol. Pflanzen. *177*, 509—514.

ACTA BIOL. SZEGED. 34. PP. 35—43 (1988)

INFLUENCE OF VARIOUS STRESS EFFECTS ON ETHYLENE PRODUCTION IN WHEAT SEEDLINGS

I. GAÁL[1], H. ARIUNAA[1], AND M. GYURIS[2]

[1]*Department of Plant Physyology, Attila József University H—6701 Szeged, P.O.B. 654. Hungary*
[2]*Cereal Research Institute Szeged 9 Alsókikötősor H—6701 Szeged, P.O.B. 391. Hungary*

(Received: May 10, 1988)

Abstract

Ethylene formation has been investigated under influence of water stress in various of wheat seedlings. The Change in ethylene production in the function of water deficit is described by a maximum curve. The position of the maximums dependes on the wheat variety. We have found that copper and cadmium ions promote ethylene prouction in the wheat seedlings investigated. The effect of copper ions depends on the pH. Ethylene production will decrease if the pH approaches 7. No correlation was observed between ethylene production and the pH in the presence of cadmium ions. In the presence of ions mentioned above an enhancement was obtained in the ACC formation. Ethylene production evoked by these ions may be inhibited by cobalt and zinc ions. Data presented in this paper show a significant difference in the ethylene production of infected and infection- protected seedling on the 9th days. Owing to serious damages in cells we found no ethylene production in the non protected seedlings on the 15th day.
Key words: ethylene, water stress, drought tolerance, copper ions, cadmium ions, downy mildew infection.

Introduction

In recent years the term "stress" has been used for all environmental factors, wich are potentially disadvantageous for living organism. In terminology "stress resistance" is used for expressing the ability of a plant to survive an unfavorable factor and even to grow in its presence (LEVITT, 1941).

In plants a stress effect can disturb metabolic processes and evoke a change, e.g. in the membrane transport mechanism as well. If the change of environmental factors is slow, the transport process coupled to the metabolism will be disturbed only in a small degree. In case of rapid changes the consequences might be severe. (ZSOLDOS et al., 1982).

It has been observed that plants subjected to stress produce ethylene in different quantities, depending on the time course and the strength of effects (ABELES, 1973; TINGEY et al., 1976).

Stress ethylene is produced only when a disturbance occurs in the metabolism of the plant cells but no decompartmentalization has been observed yet (ELSTNER and KONZE, 1976).

Plants under drought produce larger quantity of ethylene than the controls, with accompanied reduction in the growth rate. The role of the produced ethylene in the regulation of the growth process is unclear yet.

It has been suggested that ethylene is a by-product in the plant defensive mechanism (HUXTER et al., 1979).

Stress ethylene formation has among other factors investigated under water deficit (MCKEON et al., 1982; APELBAUM and YANG, 1981).

Ethylene production is enhanced in plants by injury, e.g. wounding, and also by chemical (MC GLASSON, 1964. BOLLER and KENDE, 1980; KENDE and BOLLER, 1981; YOU and YANG, 1980; HOFMANN, et al., 1982). Plant breeders have an important task to produce drought tolerant wheat varieties. therefore they have to get data connected with this problem, we have suggested that various wheat varieties provide different quantities of ethylene under water stress and also we have made experiments to study this effect.

The authors have established that heavy metal ions getting into the soil are noxious to the organs of animals and plants. These have received considerable attention over the years as a result of increased environmental dangers from industrial, agricultural, energy and municipal sources. The sources of heavy metals and their behavior in soils and plants have been reviewed by FOY et al. (1978). Stress ethylene production is also induced by aqueous solution of metal salts (RODECAP and TINGEY, 1981). We are particularly interested in the effect of cd^{2+} on the increase of ethylene production in wheat seedlings because we have shown in an earlier paper that these ions enhance ethylene production in tobacco callus tissues (GAÁL, 1985.

It has been established that Cd^{2+} is one of the dangerous environmental ions which inhibits photosynthetic activities in plants (FRIBERG et al., 1974; WIEGEL, 1985; MAUCH, 1984), stimulates ethylene production via the same pathway like basal ethylene and regulates it in a similar way (LIEBERMAN, 1979).

Similar results have been obtained in the presence of Cu^{2+} applied to mung bean hypocotyls. An enhancement was found in the ACC content and in the rate of ethylene production but no increase was observed in SAM content (FUHRER, 1982).

Since the role of Cd^{2+} and Cu^{2+} concerning ethylene production also belonged to our range of interest, it seemed resonable to study the action of these ions on wheat seedlings.

A common feature of many plant diseases is an increase in ethylene production (ABELES, 1973; PEGG, 1976). It has been observed that ethylene production increases largely in virus infected tobacco plants (LAAT et al., 1981; PRICHARD et al., 1975; LAAT et al., 1982).

According to some wheat breeders there are wheat warieties infected by downy-mildew and yet appearing to be healthy. Considerable deficit, however, can be found in the yield at harvest. In the opinion of many authors increased ethylene synthesis can be employed as an indicator for infection (BOLLER, 1982; PEGG, 1976; YANG and PRATT, 1978; MAUCH et al., 1984).

Our aim has been to search for correlation in the ethylene production at the protected and non protected wheat seedling infected by downy-mildew.

Materials and Methods

Winter wheat (*Triticum aestivum* L. cv. GK Szeged) seeds were washed in running tap-water for 4—6 h and germinated in Petri dishes for one day at 24°C. After germination the seeds were placed on a plastic sieve in suitable plastic vessels containing $5x10^{-4}$ M $CaSO_4$ solution. The solution was renewed after the third day of growth. The seedling were grown at 25°C on a 16 h photoperiod of 7000 lux. To study the effect of metal ions ethylene production lg of wheat seedlings was put into test tubes containing 1 ml of 0,005 M citrate buffer, pH 5,6 in which metal ions were dissolved in 10^{-2} M concentration.

There were no metal ions in the control solution. After incubation the seedling were transferred into test tubes closed by serum caps. Ethylene was determined by a Type Chrom 42 gas shromatograph equipped with an aluminium oxide column and a flame ionisation detector. ACC was assayed according to LIZADA and YANG (1979).

Seedlings were frozen in liquid N2 and ground in a mortar with pestle. Two ml of 80% ethanol was added per g fresh weight and the mixture stirred for 30 min at room temperature. The homogenate was centrifuged at 10000 g for 10 min and the ACC determined in the supernatant by the method as above.

In the water stress technique, seedlings (1g) were allowed to wilt while spread in Petri dishes at room temperature (20—22°C). When the seedlings reached the desired degree of water stress as indicated by loss of fresh weight they were inserted into glass test tubes which were then closed with serum caps for the desired period. Nonstressed seedlings used as controls were inserted in test tubes containing several drops of water to maintain high RH. The sealed tubes were kept at 22°C under light. gas samples (2,4 ml) were taken periodically from each tube for ethylene analysis.

To study effect of infection the wheat seedlings were cultured at 70—80 RH and 20—25°C in greenhouse. Then seeds were sown in each chambers and twenty chambers were used per the experiments. Ten of them represented the controls.

The procedure of infection: On the wheat varieties sensitive to downy-mildew infection the fungus was allowed to proliferate. From these infected seedlings the fungus was transferred on the experimental plants by shaking. Plants were infected by downy-mildew when they had two leaves.

Before infection the control plants were sprayed with a protecting material (Bayleton 25 WP, Bayer (Triadimefon)).

Plants were harvested for experiments after sowing on the 9th and 15th day.

Results and Discussion

Effect of pH

According to our results the rate of ethylene production shows no change between pH 3—7 in the presence of Cd^{2+} but decreases in the precense of copper ions when the pH approaches to 7 (Table 1). We propose the hypothesis that the copper ions from a complex or enhance the production of MACC conjugate from ACC as it has already been established by KIONKA and AMRHEIN. (KIONKA and AMRHEIN, 1984).

Effect of water stress

drought tolerant wheat varieties lose their water content slower than non-drought tolerant ones (private opinion of some wheat breeders). Data presented in this paper show that a connection can be found between water deficit and ethylene production in wheat seedlings (Fig 1.) Change in the rate of ethylene production depending on water deficit are described by a maximum curve. GK Szemes provides the highes and D—22 the lowest ethylene maximum.

Table 1. Effect of pH on ethylene production of wheat seedlings in presence of cadmium and copper ions

	Ethylene production nl/gh Treatments		
pH	Control	Cu^{2+}	Cd^{2+}
3	0.73 ± 0.2	17.5 ± 1.2	8.3 ± 0.7
4	0.95 ± 0.32	16.4 ± 1.6	7.3 ± 1.5
5	0.62 ± 0.4	16.7 ± 1.4	8.7 ± 0.97
6	0.76 ± 0.35	10.7 ± 0.6	9.1 ± 0.75
6,6	0.48 ± 0.26	7.6 ± 0.65	10.1 ± 0.97

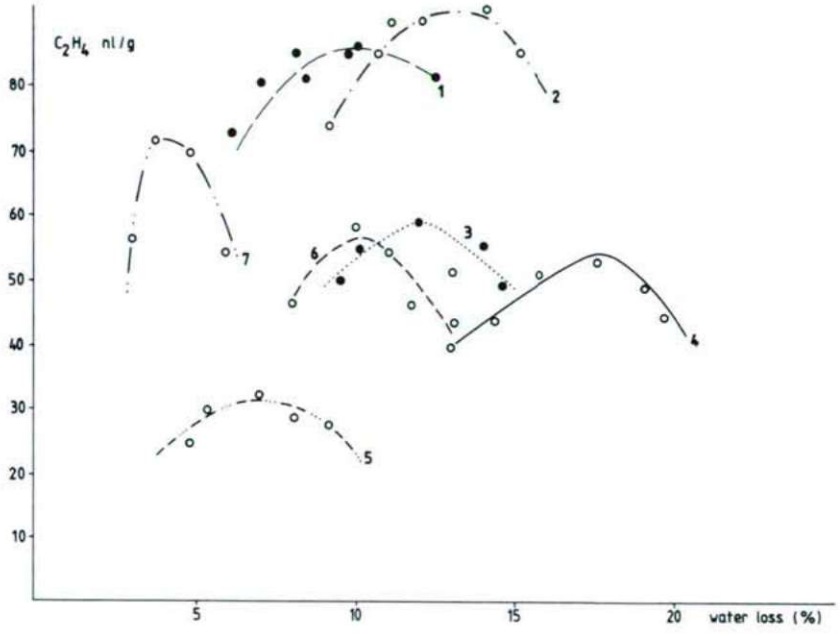


Fig. 1. Ethylene production of 9- day old seedlings of different wheat varieties in function of percentage water deficit.
1. GK Boglár; 2. GK Szemes ATK; 3. GK Kincsõ; 4. GK Minaret SE; 5. D-22.
6. Jubilejnaja 50; 7. GK Szeged.

The position of maximums deviates according to water loss, from one another. It can be concluded from these data that wheat variety GK Szemes represents the worst and Minaret SE the best one in terms of drought resistance. The result would be interesting for all who are engaged in the wheat production. It is be expected that plant breeders having this information can establish easier which are the best wheat varieties with a view to drought resistance.

Effect of metal ions

At a concentration higher then 10^{-4} M copper (II) ions seem to be a more powerful activator than cadmium (II) ions of ethylene evolution. (Fig. 2). The rate of ethylene production changes according to a maximum curve as a function of time and the position of the maximum is found about three hours (Fig. 3).

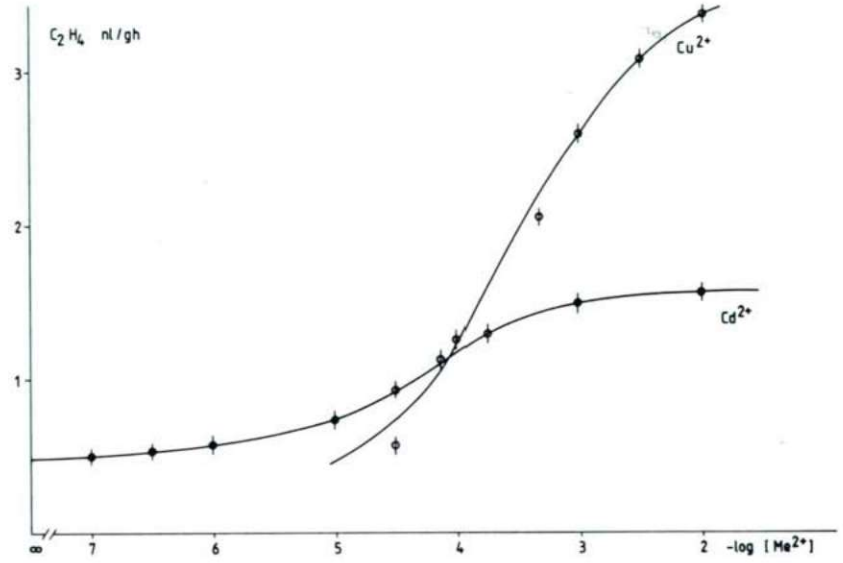


Fig. 2. Changes of ethylene production in function of metal ion concentration.

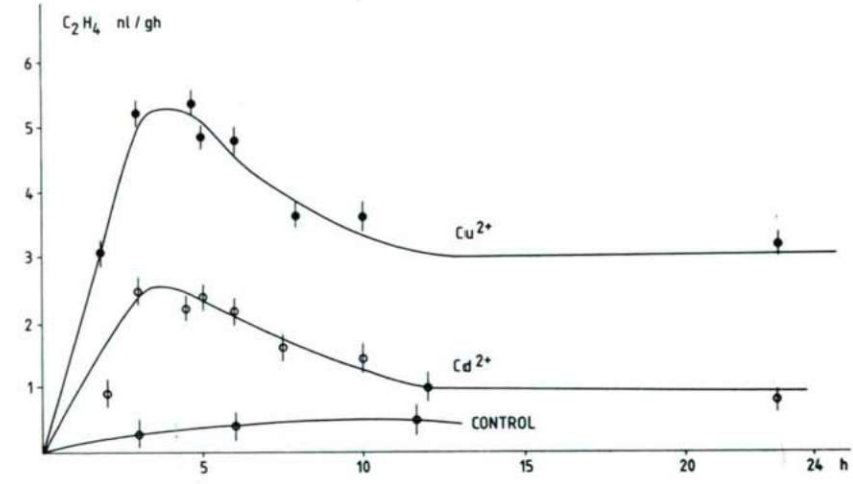


Fig. 3. Time course for effect of metal ions on ethylene production.
$\cdot = Cu^{2+}$; $o = Cd^{2+}$. $[Me^{2+}] = 10^{-2}$ M/l.

Our findings indicate that ethylene production provoked by Cu and Zn ions can be inhibited by Co^{2+} and Zn^{2+} as well (Figs. 4,5). Zn ions inhibit ethylene production also in the presence of 10^{-3} M exogenous ACC concentration (Fig. 6). Co^{2+} has already been shown to be an inhibitor of ethylene production from ACC

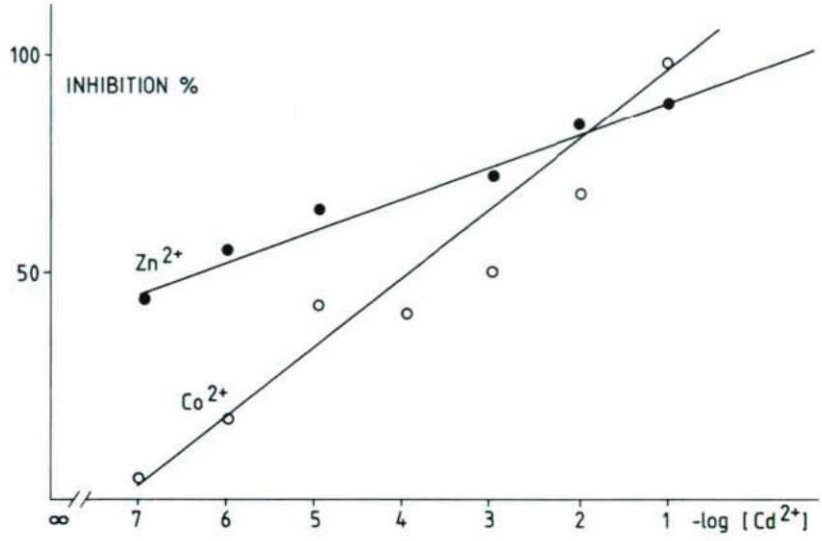


Fig. 4. Effect of cobalt and zinc ions on ethylene production evoked by copper ions. o = Co^{2+}; · = zinc ion.

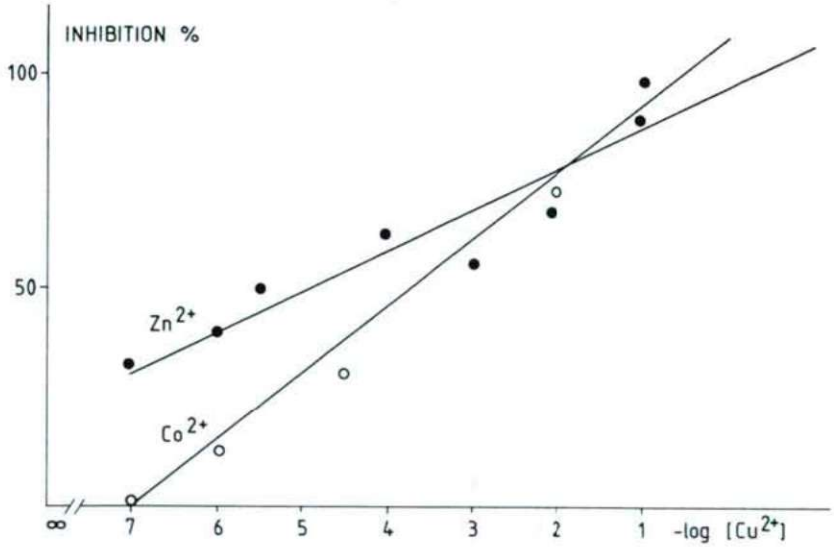


Fig. 5. Effect of cobalt and zinc ions on ethylene production evoked by cadmium ions. o = Co^{2+} · = zinc ions.

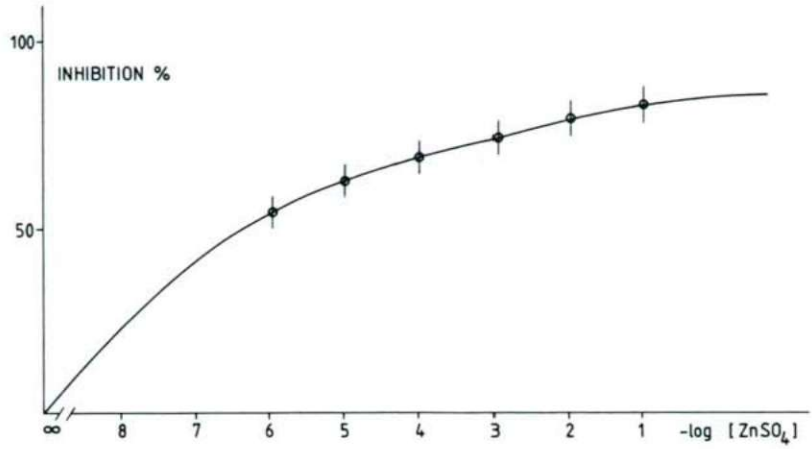


Fig. 6. Effect of zinc ions on ethylene production in the presence of exogenous ACC.

but no data could be found concerning this finding in the literature. It seems likely that cobalt ions can be substituted with Zn^{2+} in the inhibition process as it has already been observed in the case of metalloenzymes (KADDEN, 1974; KENEDDY, 1972).

Effect of the downy mildew infection

Our results demonstrate that downy-mildew produces ethylene in larges quantities on the days after infection. The infection of wheat seedlings can be prevented by triadimefon 25. In Tables 2—3 P stands for the protected, I the infected wheat seedlings in respect to ethylene production. D means the degree of infection. It can be established that a significant difference exists between the protected and unpro-

Table 2. Ethylene production of four wheat varieties on the 9th day of infection

		Ethylene production nl/gh			
Varieties	D	P	I	I—P	% change
GK Réka	0	0.36	0.33	0.04	—9.64
GK Ságvári	4	0.67	2.17	1,48	216.01
Mini Manó	2	0.61	1.1	0.48	78.31
Arthur	0	0.46	0.7	0.25	54.02
Average		0.53	1.1		102.6
SD 5% between main averages 0.13					
SD 5% between the varieties 0.19			in the same block		
SD 5% between any two values 0.27					

(Data in Table 2 are means of three experiments. D: degree of infection; P: protected; I: infected wheat seedlings)

Table 3. Ethylene production of four wheat seedling varieties on the 15th day of infection

		Ethylene production nl/gh			
Varieties	D	P	I	I—P	% change
GK Réka	0	0.37	0.26	—0.11	—30.58
GK Ságvári	4	0.54	0.50	0.04	—9.87
Mini Manó	2	0.40	0.50	0.10	24.30
Arthur	0	0.42	0.41	0.01	—3.21
Average		0.44	0.42		—4.75

SD 5% between main averages 0.086
SD 5% between the varieties 0.122
SD 5% between any two values 0.172

(Data in Table 2 are means of three experiments. D: degree of infection; P: protected; I: infected wheat seedligs)

tected wheat seedlings in the rate of ethylene production on the 9th day after infection, however, no ethylene production was observed after infection on the 15th day because of the serious damage of cells responsible for ethylene production.

The results show that a downy-mildew infection can be assumed if the ethylene production increases in wheat seedlings and this provides a possibility for protection in time.

Abbreviations: ACC = 1-aminocyclopropane-1-carboxylic acid
MACC = 1-(malonyl-amino) cyclopropane. carboxylic acid
ATK = mixture of cultivars
SE = Super Elite

References

ABELES, F.B. (1973): Ethylene in Plant biology. Academic Press, New York.

APELBAUM, A. and YANG, S.F. (1981): Biosynthesis of stress ethylene induced by water deficit. — Plant Physiol. *68*, 594—596.

BOLLER, T. and KENDE, H. (1980): Regulation of Wound ethylene synthesis in plants. — Nature *286*, 259—260.

BOLLER, T. (1982): Ethylene induced biochemical defences against pathogens in: Wareing, P.F. (ed): Plant growth substances 1982 pp. 303—312. Academic Press, London.

ELSTNER, E.F. and KONZE, I.R. (1976). Effect of point freezing on ethylene and ethane production by sugar beet leaf disks. — Nature *263*, 351—352.

FOY, C.D., CHANEY, R.L. and WHITE, M.C. (1978): The physiology of metal toxicity in plants. — Ann Rew. of Plant Physiol. *29*, 511—556.

FRIBERG, D.M., PISCATOR, G.F., NORBERG, A. and KJELLSTRÖM, T. (1974): Cadmium in the environment. — CRC Press Cleveland.

FUHRER, J. (1982): Ethylene biosynthesis and cadmium toxitity in leaf tissue of beans. — Plant Physiol. *70*, 162—167.

GAÁL, I. (1985): A Cd^{2+} hatása az etilénképződésre dohány szövettenyészetben. (Effect of Cd^{2+} on the ethylene production in the tissue culture) — Botanikai Közlem. *72*, 277—282.

MC GLASSON, W.B. and PRATT, H.K. (1964): Effect of wounding on respiration and ethylene production by cantaloupe fruit tissues. — Plant Physiol. *39*, 128—132.

HOFFMANN, N.E. and YANG, S.F. (1982): Enhancement of wound induced ethylene synthesis by ethylene in preclimacteric cantaloupe. — Plant Physiol. *69*, 317—322.

HUXTER, T.J., DAVID, M.R. and THORPE, T.H. (1979): Ethylene production by tobaco (*Nicotiana tabacum*) callus. — Physiol. Plant. *46*, 374—380.

KADDEN, T.A., HOLMGUIST and VALLEE, B.L. (1974): magnetic circular dichroism of cobalt II complexes. — Inorg. Chem. *13*, 2585—2590.

KENDE, H. and BOLLER, T. (1981): Wound ethylene and 1-aminocyclopropane 1-carboxylate synthase in ripening tomato fruit. — Plant *151*, 478—481.

KENNEDDY, F.S.,HILL, M.A. KADEN, Q. and VOLLEE, B.L. (1972): Electron paramagnetic resonance spectro of some active cobalt II substitued metalloenzymes and other cobalt (II) complexes. — Biochem. Biophys. res. Comm. *48*, 1533—1539.

MC KEON, T.A., HOFFMANN, N.E. and YANG, S.F. (1982). the effect plants hormone pretreatments on ethylene production and synthesis of 1-aminocyclopropane-1-carboxylic acid in water sressed weat leaves. — Planta *155*, 437—443.

KIONKA, C. and AMRHEIN, N. (1984): The enzymatic malonylation of 1-amino cyclopropane-1-carboxylic acid in homogenates of mung- bean hypocotyls. — Plant *162*, 226—235.

LAAT, A.M.M. and VON LOON, L.C. (1982): Regulation of ethylene biosynthesis in virus infected tobacco leaves. — Plant physiol. *69*, 240—245.

LEWITT, J. (1972): The Nature Of Stress Injure And Resistance.. In: Lewitt, J. (ed.): Responce of plants to environmental stresses. Academic Press, New York London. Volume I. 1—18.

LIEBERMAN, M. (1979): biosynthesis and action of ethylene. — Ann Rew. of Plant Physiol. *30*, 533—591.

LIZADA, C. and YANG, S.F. (1979): A simple and sensitive assay for 1-aminocyclopropane -1- carboxylic acid. — Analytical Biochemistry *100*, 140—145.

MAUCH, F. (1984): Ethylene: Symptom, not signal for the Induction of chitinase and β —1,3 — glucanase in pea pods by Pathogens and elicitors — Plant Physiol. *76*, 607—611.

PEGG, G.F. (1976): The involvement of ethylene in plant pathogenesis. —In: Encyclopedia of Plant Physiology, New series, Vol. 4. Springer Verlag, Heidelberg, pp. 558—591.

PRICHARD, D.W. and ROSS, A.F. (1975): The relationship of ethylene to formation of tobacco mosaic virus lesions in hypersensitive responding tobacco leaves with and without induced resistance. — virology, — *64*, 295—307.

RODECAP, K.D., TINGEY, D.T. and TIBBS, J.H. (1981): cadmium—induced ethylene production in bean plants. — Z. Pflanzenphysiol. *105*, 65—74

TINGEY, D.T., STANDLEY, C. and FIELD, R.W. (1976): Stress ethylene evolution: a measure of ozone effects on plants. — Atmos. Environ. *10*, 969—974.

WEIGEL, H.I. (1985). Inhibition of photosynthetic reactions of isolated intact cloroplasts by cadmium. Journal. Plant Physiol. *119*, 179—189.

YANG, S.F. and PRATT, M.K. (1978): The physiology of ethylene in wounded plant tissue. — In. G.K. KOHL, (ed.): Biochemistry of wounded plant tissues- Walter de Gruyter, Berlin, pp. 595—622.

YOU, Y.B. and YANG, S.F. (1980). Biosynthesis of wound ethylene. — Plant Physiol. *66*, 281—285.

ZSOLDOS, F. (1982): Stressztényezők hatása termofil növények kálium transzportjára. (stressefects on the transport of potassion ions in the thermophilous plants). — MTA Biol. Oszt. közl. *25*, 623—636.

ACTA BIOL. SZEGED. 34. PP. 45—57 (1988)

PALEOPHYTOGEOGRAPHY OF THE ANGIOSPERM POLLEN GRAINS DURING THE UPPER CRETACEOUS AND THE TERTIARY II

M. KEDVES

Department of Botany, Attila József University H—6701 Szeged, P.O.B. 657, Hungary

(Received: November 10, 1987)

Abstract

Continuing a previous paper recently mostly Longaxones pollen grains and tetrads were investigated from the point of view of regional and time scale distribution. The form-taxa studied are as follows: *Pistillipollenites, Psilatricolporites parmularius, Nyssapollenites, Cyrillaceaepollenites, Ilexpollenites, Tetracolporopollenites, Ericipites* and *Droseridites*. Each pollen type is firstly of Eurasian distribution. Occurrences from the Southern Hemisphere are: *Pistillipollenites* from Australia, *Cyrillaceaepollenites* from Indonesia, *Ilexpollenites* from Indonesia, Australia, New Zealand and from the Falkland Islands, *Tetracolporopollenites* from Australia and New Zealand, *Ericipites* from South America, Africa, Australia and New Zealand. But all appearances from the Upper Cretaceous are from the Northern Hemisphere.

Key words: Palynology, Paleophytogeography, Cretaceous — Tertiary.

Introduction

In a previous paper (KEDVES, 1987) it was pointed out, that apart from the Normapolles and *Aquilapollenites* group other kinds of angiosperms pollen grains as Postnormapolles, and further ones from other morphological groups are or may be important in paleophytogeographical respect during the Cretaceous — Tertiary period. Following the first such synthesis in this paper I have chosen angiosperm pollen grains of heterogeneous type in morphological, taxonomical and ecological respect for paleophytogeographycal evaluation. The method of collecting and elaborating the bibliographical data correspond to that essentially used in the previous paper (KEDVES, 1987).

Results

Fgen.: *Pistillipollenites* ROUSE 1962 (Fig. 1)

ELSIK (1968) emended this form-genus and included also colpoidorat pollen grains here. ROUSE and SRIVASTAVA (1970) have not accepted this emendation, and completed the knowledge of these pollen grains with SEM data. The earliest occurrence, the appearance of this form-genus (Upper Cretaceous) is in North America in the *Aquilapollenites* province, and in the so-called intermediate region. There are data until the Oligocene, this latter, being the most recent occurrence, is

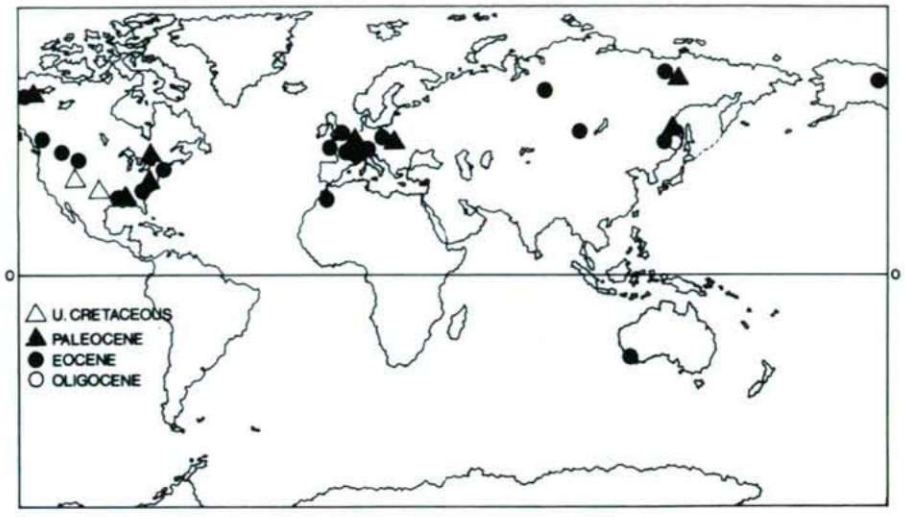


Fig. 1. Regional distribution of *Pistillipollenites* ROUSE 1962 during the Upper Cretaceous and the Tertiary.

also known from the *Aquilapollenites* province, but from the Far East of Asia. The acme of these pollen grains was during the Eocene, but we have several data from the Paleocene, too. On the basis of our up-to-date knowledge this is the microfossil of the Northern Hemisphere, but it is known from Australia, too. Till this time we have no data from South America, Africa, India, and from China. As regards Europe, today we have no data from the Mediterranean Region. In this way in all probability at least in European relation this kind of pollen grain is the component of the spore-pollen assemblages of the Boreal Region.

Fgen.: *Psilatricolporites* (VAN DER HAMMEN 1956) VAN DER HAMMEN et WIJMSTRA 1964

Ps. parmularius (R. POT. 1934) KDS. 1978 (Fig. 2) .

Basionym: 1934, R. POTONIÉ. — *Pollenites parmularius* n. sp., p. 52, tab. 2, fig. 7, tab. 6, fig. 11.

Syn.: 1953, THOMSON et PFLUG. — *Tricolpopollenites parmularius* (R. POT.) n. comb., p. 97, Taf. XI, 152—162.

1960, KRUTZSCH (in KRUTZSCH, PCHALEK ET SPIEGLER). — *Tricolporo pollenites parmularius* (R. POT. 1934b) n. comb., p. 140, fig. 94.

1960, Potonié. — *Cornaceoipollenites* (al. *Pollenites) parmularius* (R. POT. 1934) R. POT. 1951, p. 93.

1974, ANANOVA. — *Eucommia parmularia* (R. POT,) ANAN. comb. nov., p. 174.

The botanical affinity of this pollen type is the Eucommiaceae, genus Eucommia. This was pointed out in several publications, but it was ANANOVA (1974) who

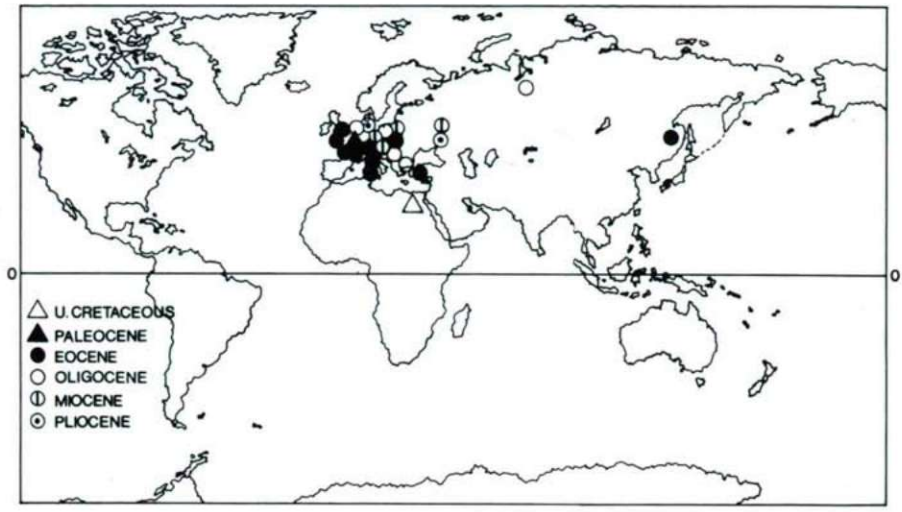


Fig. 2. Regional distribution of *Psilatricolporites parmularius* (R. POT. 1934) KDS. 1978 during the Upper Cretaceous and the Tertiary.

emphasized it definitely. Taking into consideration the book of KUPRIYANOVA (1965), this statement seems to be without doubt. But the pollen grains of genus *Eucommiidites* from the Jurassic, originate from gymnospermous tree; cf. BRENNER (1976).

The appearance of Ps. parmularius is in the Upper Cretaceous in Egypt, and this is at the same time the single occurrence apart Eurasia. In Europe it occurs till to the Pliocene, in Siberia (*Aquilapollenites* province) occurs in the Eocene and Miocene. On the basis of our present day knowledge, this pollen species is firstly the element of the European Eocene, or Paleogene spore-pollen assemblages, and is useful for stratigraphical purposes only in a restricted region. But the restricted occurrence outside Europe may not be taken as decisive; with further data essential changes may be presumed.

Fgen.: *Nyssapollenites* THIERGART 1937 (Fig. 3)

The botanical affinity of this pollen grain is the Nyssaceae or Mastixiaceae. The earliest occurrence is in the Upper Cretaceous: North America (Normapolles and *Aquilapollenites* province), Europe, Egypt, and China. This form-genus is largely widespread over the whole Asia. This distribution is characteristic for further geological ages up to the Quaternary. From Africa (Equatorial part) we have data from Miocene and Pliocene layers. In spite of the fact that the number of publications concerning this kind of pollen grain is large, with further investigations on African, South American and Australian localities this question may be put in another light, the regional distribution of the Nyssaceae (v. Mastixiaceae) in the geological past.

Fgen.: *Cyrillaceaepollenites* (MÜRRIGER et PFLUG 1951) R. POT. 1960 (fig. 4)

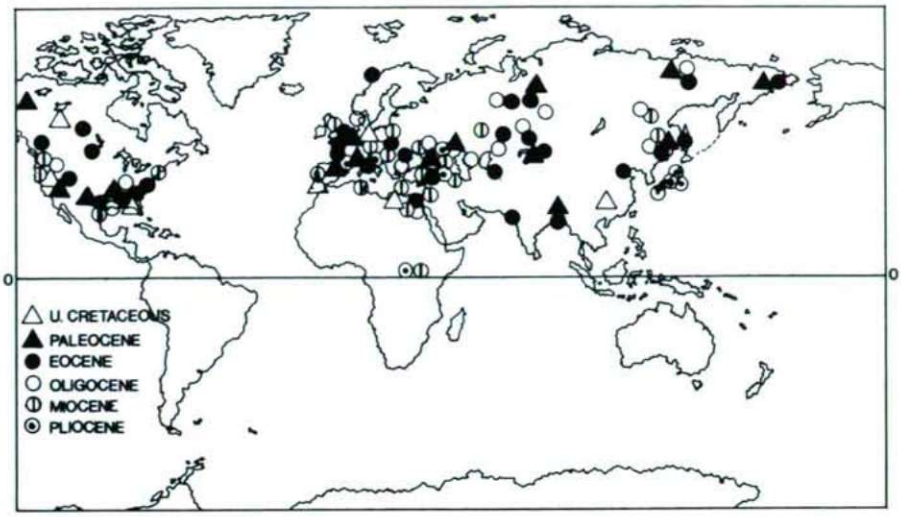


Fig. 3. Regional distribution of *Nyssapollenites* THIERGART 1937 during the Upper Cretaceous and the Tertiary.

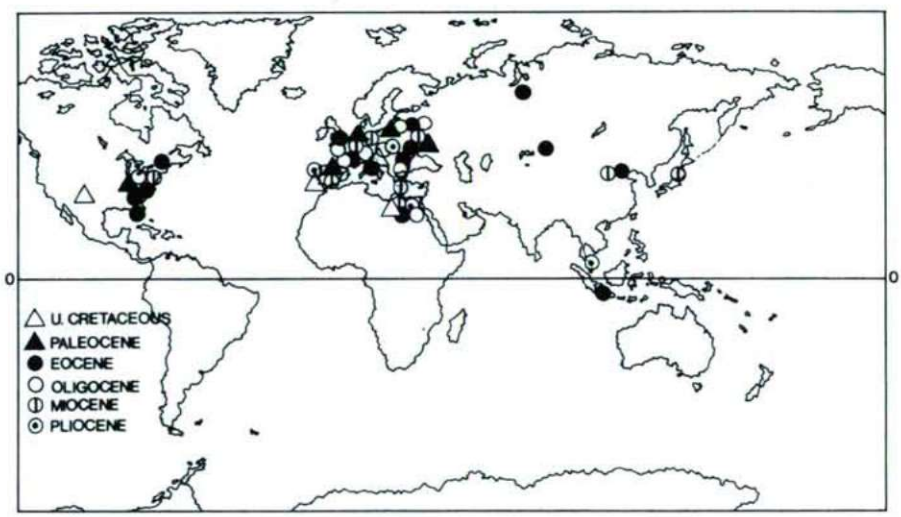


Fig. 4. Regional distribution of *Cyrillaceaepollenites* (MÜRRIGER et PFLUG 1951) R. POT. 1960 during the Upper Cretaceous and the Tertiary.

The earliest, Upper Cretaceous occurrence is in North America in the *Aquilapollenites* province, and in North Africa. From the Paleocene we have data only from Europe, and North America. The largest distribution was during the Eocene, in this period beyond the above mentioned localities occur in the Normapolles province of North America, and in Asia. During the Miocene Cyrillaceae — Clethraceae (or Theaceae) was one of the elements of the brown-coal forming vegetation zonation.

Fgen.: *Ilexpollenites* (THIERGART 1937) R. POT. 1960 (Fig. 5)

The appearance of this pollen type is in the Upper Cretaceous of the Northern Hemisphere, where there are data from several localities. At the present day we have relatively few data from the Southern Hemisphere, except Australia. On the basis of the distribution map several restrictions may be established during the Pliocene, and in the relation of Africa a migration in the southern direction.

Fgen.: *Tetracolporopollenites* PF. et TH. 1953 (Fig. 6)

The appearance of this pollen form-genus is in the Upper Cretaceous, in Europe in the Normapolles, in North America in the *Aquilapollenites* province. These pollen grains were extremely widespread during the Eocene, whereas except South America occur in all continents. This was the beginning of the golden age of the fossil Sapotaceae pollen grains, which extend up to the Pliocene. At the end of the Tertiary a reduction may be established. Concerning the Eurasian distribution it is worth of mentioning that at this moment we have no data from Siberia.

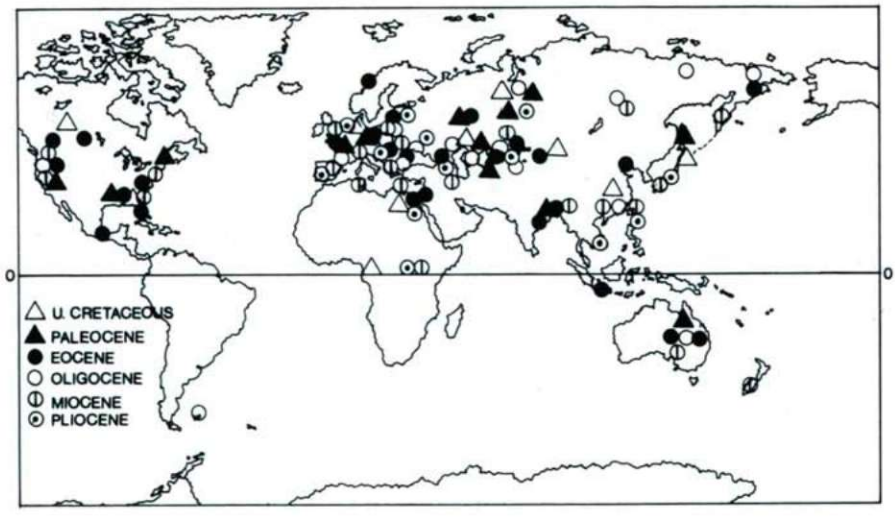


Fig. 5. Regional distribution of *Ilexpollenites* (THIERGART 1937) R. POT. 1960 during the Upper Cretaceous and the Tertiary.

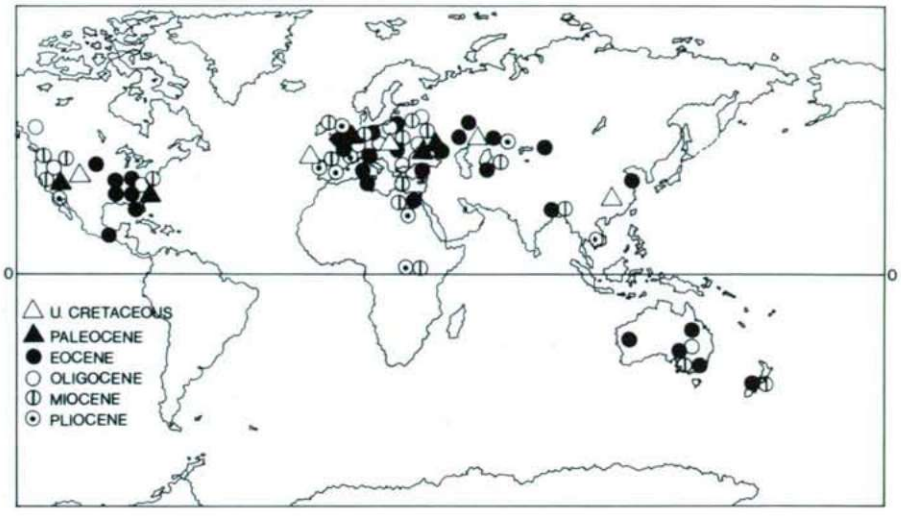


Fig. 6. Regional distribution of *Tetracolporopollenites* PF. et TH. 1953 during the Upper Cretaceous and the Tertiary.

Fgen.: *Ericipites* WODEHOUSE 1933 (Fig. 7)

This pollen type was very widespread in the Northern Hemisphere during the Upper Cretaceous. In contrast to this, from the regions of the southern part of the present day Equator the first data are known from the Paleocene of Africa, Aust-

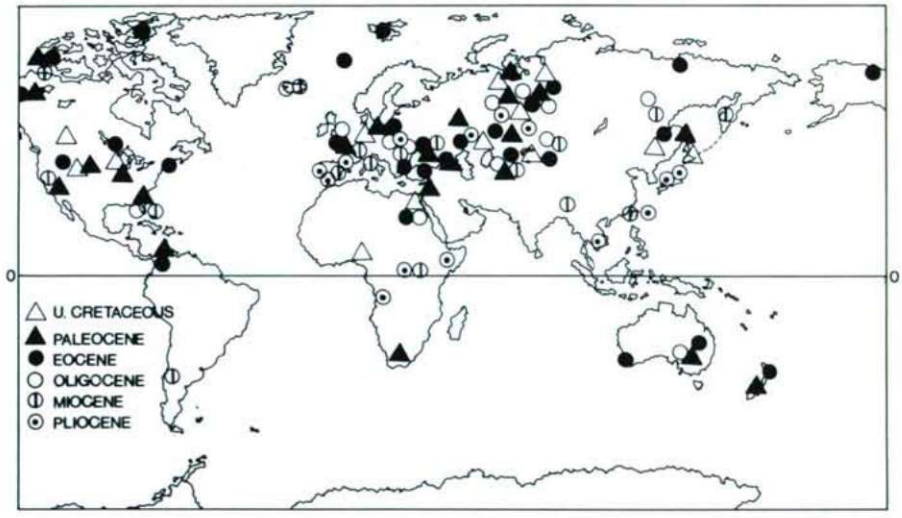


Fig. 7. Regional distribution of *Ericipites* WODEHOUSE 1933 during the Upper Cretaceous and the Tertiary.

ralia and New Zealand. The palynological data suggest a migration in the southern direction during the Tertiary period of Africa and the Far East. From South America till this time we have relatively few data.

Fgen.: *Droseridites* COOKSON 1947 (Fig. 8)

Relatively rare pollen type, on the basis of our up-to-date knowledge we have data from Eurasia and Africa. Appearance in the Upper Cretaceous of Africa and of the Iberian Peninsule. During the Eocene this was relatively largely widespread. Worth of mentioning is its paleoecological importance.

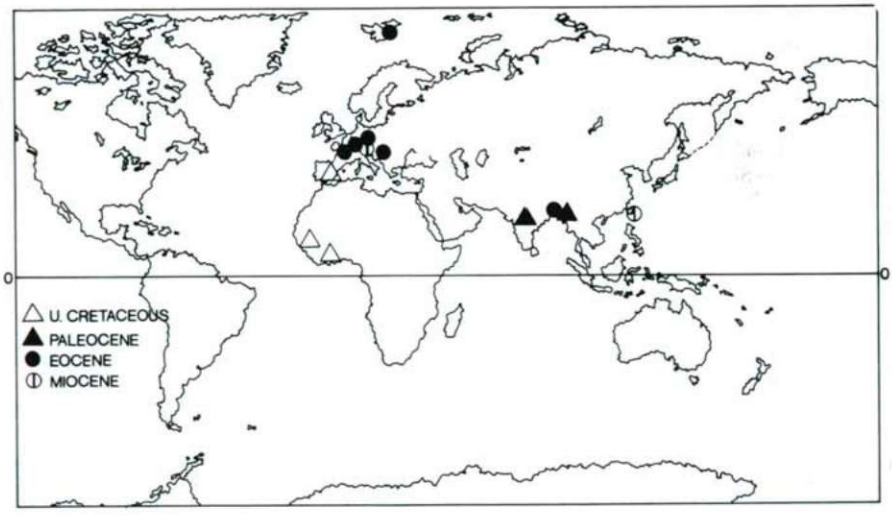


Fig. 8. Regional disribution of *Droseridites* COOKSON 1947 during the Upper Cretaceous and the Tertiary.

Conclusions

The paleophytogeographical evaluation of the spore-pollen groups, which were neglected till this time need long time and a lot of energy. But the changes of the regional distribution during the geological past of the pollen types give opportunity to construct new synthesis and conclusions. Moreover several new problems arise as well which in some cases indicate new researches in this field. Naturally we must stress again and again that in some cases it must be taken into consideration that our knowledge is not sufficient, during the evaluation of the data. Taking into consideration the regional distribution of the up-to-date elaborated taxa it may be established that investigation and publications are centered firstly to the Northern Hemisphere. It is necessary to study this problem, based on the types for the taxa, which are characteristic for the Southern Hemisphere.

Appendix

The data of the following publications were used for the distribution maps.

ABUZYAROVA, 1954, Abstr., Alma-ata, 1—16: ABUZYAROVA, 1955, Data concerning the history of the faune and flore of Kazakhstan, 1, 126—137; ABUZYAROVA, 1962, For the First Internat. Palynol. Conf. (Tucson, USA), 120—125; ABUZYAROVA, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 165—168; ABUZYAROVA, 1970, Bot. J. 55, 1121—1126; AKHMETEEV, BRATSEVA, GITERMAN, GOLUBAEVA — MOISEEVA, 1978, Acad. Sci. URSS, 316, 1—316; ALEXANDROVA, 1973, The Palynology of Cenophytic, 145—149; ALEXANDROVA, BESPROZVANNYKH — GORYUKHIN, 1971, Material for Paleopalynology of West Siberia, 73—89; ANANOVA, 1960, Paleophytogeography and Stratigraphy of Quaternary and Tertiary Sediments, 6—41; ANANOVA, 1962, For the First Int. Palynol. Conf. (Tucson, USA), 137—144: ANANOVA, 1973, The Palynology of Cenophytic, 165—170; ANANOVA, 1974, Bull. Univ. Leningrad; ANDERSON, 1960, State Bur. of Min. and Min. Res. New Mexico 6, 1—59; ARISTOVA, 1973, The Palynology of Cenophytic, 117—121; AUFFERT — GRUAS-CAVAGNETTO, 1975, Bull. de la Soc. géol. de France 7e, 17, 641—655; BALTES, 1971, Rev. Palaeobot. Palynol. 11, 125—158; BAKSI, 1973, The Palynology of Cenophytic, 78—88; BANERJEE, 1964, Bull. of the Geol. Min. and Metall. Soc. of India 29, 1—8; BANERJEE, MISRA — KOSHAL, 1971, The Palaeobotanist 20, 1—6; BARBASHINOVA — Shugaevskaya, 1962, For the First Internat. Palynol. Conf. (Tucson, USA), 131—135; BEBOUT, 1980, Palynology 4, 181—196; BENDA, 1971, Beih. geol. Jb. 113, 1—46; BENDA, MEULENKAMP — ZACHARIASSE, 1974, Newsl. Stratigr. 3, 205—217; BESSONENKO, 1968, Paleopalynological Method for Stratigraphy, 151—156; BESSONENKO, 1971, Material for Paleopalynology of West Siberia, 59—63; BLYAKHOVA, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 127—131; BLYAKHOVA, 1971 Palynology of Kazakhstan, 114—127; BLYAKHOVA 1976, Palynology of Kazakhstan, 69—77; BLYAKHOVA, KALMENEVA — PONOMARENKO, 1971, Palynology of Kazakhstan, 93—106; BOITSOVA — PANOVA, 1967, Stratigraphy and Paleontology of Mesozoic and Paleogene continental layers of the Asiatic part of the URSS, 262—270; BOITSOVA — PANOVA, 1976, Palynology of the URSS, 96—99; BOITSOVA — VASILIEV, 1960, XXI. Int. Geol. Cong., 236—246; BOLOTNIKOVA, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 131—136; BOLTENHAGEN, 1976, Cahiers de Micropaléontologie 3, 1—21; BONDARENKO, 1961, Paleontology and Biostratigraphy of the Soviet Arctic, 124, 97—136; BONDARENKO, 1973, Palynology of Cenophytic, 8—12; BONNEFILLE, 1974, Ass. Sénégal. Et. Quatern. Afr., Bull. Livraison, Sénégal, 42—43, 21—32; BOULTER, 1971, Bull. of the British Museum 19, 361—410; BRATSEVA, 1969, Acad. Sci. URSS, 207, 1—56; BRATSEVA, 1976, Palynology of the URSS, 116—119; BRELIE, 1968a, Z. Deutsch. Geol. Ges. 118, 186—191; BRELIE. 1968b, Fortschr. Geol. Rheinld. u. Westf. 16, 85—102; BRELIE, HAGER — WEILER, 1981, Fortschr. Geol. Rheinld. u. Westf. 29, 21—58; BRELIE, QUITZOV — STADLER, 1969, Fortschr. Geol. Rheinld. u. Westf. 17, 27—40; BRENNER, 1976, Origin and Early Evolution of Angiosperms, 23—47; BUDRIN — GROMOVA, 1973, Paleopalynological Method for Stratigraphy 195, 180—184; BUDNAR-TREGUBOV, 1961, Zavod za Geoloska i Geofizicka Istrazivanja 19, 279—286; CANRIGHT, 1972, Symposium on Stratigraphical Palynology, 117—124; CARATINI, 1975, B.S.G.F. 17, 797—803; CARBONNEL, CHATEAUNEUF, FEIST-CASTEL, GRACIANSKY — VIANEY-LIAUD, 1972, C. R. Acad. Sc. Paris 275, 2599—2602; CAVAGNETTO, 1964, Rev. de Micropaléont. 7, 57—64; CERNJAVSKA, 1967a, Bull. of the Geol. Inst. of the Bulgarian Acad. Sci. 16, 95—130; CERNJAVSKA, 1967b, Abh. zentr. geol. Inst. 10, 177—180; CERNJAVSKA, 1970, Bulgarian Acad. Sci. Commission for Geology 19, 79—100; CERNJAVSKA — PETKOVA, 1968, Bulgarian Acad. Sci. Commission for Geology 17, 241—276; KHAIKINA — BELAYA, 1968, Paleopalynological Method for Stratigraphy, 157—163; CHATEAUNEUF — GRUAS-CAVAGNETTO, 1968, Mém. du B.R.G.M. 59, 113—159; CHATEAUNEUF — TRAUTH, 1972, Mém. du B.R.G.M. 77, 329—336; CHOUX, DURAND — MILON, 1961, C.R. Acad. Sc. Paris 252, 3833—3835; CHRISTOPHER, PROWELL, REINHARDT — MARKEVICH, 1980, Palynology 4, 105—124; COMBÉMOREL,GUÉRIN — MÉON-VILAIN, 1970, Bull. du B.R.G.M. 4, 33—47; CORSIN — NAKOMAN, 1967, Ann. de la Soc. Geol. du Nord 87, 39—53; COUPER, 1960, New Zealand Geol. Survey, Paleont. Bull. 32, 1—87; DE PORTA, KEDVES, SOLÉ DE PORTA — CIVIS, 1985, Rev. d'Invest. Geol. 40, 5—58; DEÁK, 1960, Földtani Közlöny 90, 125—131; DEMARCQ, MÉON-VILAIN, MIGUET — KUJAWSKI, 1976, Notes du Service Géol. de Tunisie 42, 97—145; DINIZ, 1967, Rev. Palaeobot. Palynol. 5, 263—268; DINIZ, 1969, Naturalia monspeliensis 20, 77—88; DINIZ, 1972, Bol. do

Museu e Lab. Miner. e Geol. da Fac. de Ciencias 13, 83—95; DINIZ, 1984, Thèse USTL, Montpellier, DOERENKAMP, JARDINÉ — MOREAU, 1976, Bull. of Canadian Petroleum Geology 24, 372—417; DOUBINGER, 1972, C.R. Soc. Biogéographie 427, 17—25; DOUBINGER, 1973, C.R. du Congr. Nat. des Soc. Savantes 5, 253—262; DÖRING, KRUTZSCH, MAI — SCHULZ, 1966, Abh. zentr. geol. Inst. 8, 112—149; DRUGG, 1967, Palaeontogrphica B, 120, 1—71; DURAND, 1957, C:R: Acad. des Sci. 244, 2629—2632; DURAND, 1958, C.R. Acad. des Sci. 247, 1753—1756; DURAND, 1960a, Bull. de la Soc. Géol. et Miner de Bretagne, N.S. 2, 71—80; DURAND, 1960b, Mém. de la Soc. Géol. et Miner. de Bretagne, 1—389; DURAND, 1962, Coll. sur le Paléogène, 1001—1008; DURAND — ESTÉOULE-CHOUX, 1962, C.R. des séances de l'Acad. des Sci. 254, 334—336; DURAND, ESTÉOULE-CHOUX, OLLIVIER-PIERRE — REY, 1973, C.R. des séances de l'Acad. des Sci. 276, 701—703; DURAND — REY, 1963, C.R. des séances de l'Acad. des Sci. 257, 2692—2693; DURAND — STEINBERG, 1965, C.R. des séances de l'Acad. des Sci. 261, 4162—4165; DZHABAROVA, 1973, The Palynology of Cenophytic, 173—177; DZHABAROVA, 1976, Palynology of the URSS; EGOROVA, 1973, The Palynology of Cenophytic, 188—192; ELSIK, 1965, Diss. D. of Ph. Texas A. et M. Univ., 1—197; ELSIK, 1968a, Geol. Soc. of America South-Central Sect. 18, 19; ELSIK 1968b, Pollen et Spores 10, 599—664; ELSIK 1968c, Houston Geol. Soc., 22—27; ELSIK, 1974a, Palaeontographica B, 149, 90—111; ELSIK, 1974b, Geoscience and Man 9, 73; ENGELHARDT, 1964, Mississippi Geol. Res. Papers 104, 65—95; ESENALINOV — PASKAR, 1976, Palynology of Kazakhstan, 78—81; ESTÉOULE-CHOUX — OLLIVIER-PIERRE, 1973, C.R. des séances de l'Acad. des Sci. 277, 633—635; FAIRCHILD — ELSIK, 1969, Palaeontographica B, 128, 81—89; FISK, 1976a, Geol. Soc. of America, Abstr. with Programs 8, 273; FISK, 1976b, Diss. Abstr. Internat. 37, 1—3; FOSTER, 1982, Geol. Surv. of Queensland 381, 1—33; FRADKINA, 1976, Palynology of the URSS; FRADKINA — BARANOVA, 1973, The Palynology of Cenophytic, 152—156; FRADKINA, KISELEVA, ERMOLAEVA, ZHABREVA — ZHARIKOVA, 1971, For the III. Internat. Palynol. Conf., 22—39; FREDERIKSEN, 1977, U.S. Dept. of the Interior Geol. Surv., 1—27; FREDERIKSEN, 1980, Palynology, 4, 125—179; FREDERIKSEN, 1984a, In WARD and KRAFT eds., 135—151; FREDERIKSEN, 1984b, Geol. Surv. Prof. Paper 1308, 1—25; GAPONOFF, 1984, Palynology 8, 71—106; GRABOWSKA, 1965, Kwartalnik Geologiczny 9, 815—836; GRABOWSKA, 1968, Kwartalnik Geologiczny 12, 155—166; GRABOWSKA— PIWOCKI, 1975, Inst. Geol. Biul. 284, 42—70; GRAY, 1960, Science, 132, 808—810; GRAY, 1964, Ancient Pacific Floras, 21—30; GRELLER — RACHELE, 1983, Rev. Palaeobot. Palynol. 40, 149—163; GRIGOREVA, 1968, Paleopalynological Method for Stratigraphy, 131—150; GRIGOREVA — SKURATENKO, 1971, Material for Paleopalynology of West Siberia, 64—67; GROOT — GROOT, 1962, Palaeontographica B, 111, 161—171; GRUAS-CAVAGNETTO, 1966, Rev. de Micropaléont. 9, 57—67; GRUAS-CAVAGNETTO, 1967, Rev. Palaeobot. Palynol. 5, 243—261; GRUAS-CAVAGNETTO, 1968, Mém. de la Soc. Géol. de France 110, 1—144; GRUAS-CAVAGNETTO, 1969, C.R. sommaire des Séances de la Soc. Géol. de France 6, 221—222; GRUAS-CAVAGNETTO, 1970a, C.R. sommaire des séances de la Soc. Géol. de France 1, 19—20; GRUAS-CAVAGNETTO, 1970b, Pollen et Spores 12, 71—82; GRUAS-CAVAGNETTO, 1971, C.R. sommaire des séances de la Soc. Géol. de France 24, 172—173; GRUAS-CAVAGNETTO, 1972, Rev. de Micropaléont. 15, 63—74; GRUAS-CAVAGNETTO, 1973, Paléobiologie continentale 4, 1—13; GRUAS-CAVAGNETTO, 1974, Paléobiologie continentale 5, 1—20; GRUAS-CAVAGNETTO, 1976, Cahiers de Micropaléontologie 1, 1—49; GRUAS CAVAGNETTO, 1978, Mém. de la Soc. Géol. de France N.S. 56, 1—64; GRUAS-CAVAGNETTO — BIGNOT, 1985, Rev. de Micropaleontologie 4, 117—132; HALLEGOUET, OLLIVIER-PIERRE — ESTÉOULE-CHOUX, 1976, C.R. des séances de l'Acad. des Sci. 283, 1711—1714; HARRIS, 1972, Trans.R. Soc. Austr. 96, 53—65; HERNGREEN, FELDER, KEDVES — MEESSEN, 1986, Rev. Paléobot., Palynol. 48, 1—70; HOS, 1975, J. Royal Soc. West. Austr. 58. 1—14; HUANG, 1980, Taiwania, 25, 57—103; HUANG — HUANG, 1984, Taiwania 29, 15—109; HUANG — TSOU, 1984, Taiwania 29, 1—13; ILENOK, 1968, Paleopalynological Method for Stratigraphy, 188—198; JAIME DE PORTA, CIVIS — SOLE DE PORTA, 1977, Studia Geologica 13, 127—161; JAIN, KAR — SAH, 1973, Geophytology 3, 150—165; JARZEN, 1978, Pollen et Spores 20, 535—553; JARZEN — NORRIS, 1975, Geoscience and Man 11, 47—60; JONES, 1962, Trans. of the Gulf Coast Ass. of Geol. Soc. 12, 285—294; KEDVES, 1959, Acta Biol. Szeged 5, 167—179; KEDVES, 1960, Pollen et Spores 2, 89—118; KEDVES, 1961a, Acta Biol. Szeged 7, 25—41; KEDVES, 1961b, Pollen et Spores 3, 101—153; KEDVES, 1963a, Acta bot. Hung. 9, 31—66; KEDVES, 1963b, Acta bot. Hung. 9, 25—30; KEDVES, 1965, Acta Biol. Szeged 11, 33—50; KEDVES, 1965b, Acta bot. Hung. 11, 325—360; KEDVES, 1966a, Acta bot. Hung. 12, 55—88; KEDVES, 1966b, Grana Palynolo-

gica 6, 290—296; KEDVES, 1971, Acta bot. Hung. 17, 371—378; KEDVES, 1978a, Acta Biol. Szeged 24, 23—30; KEDVES, 1978b, Studia Biol. Hung. 15, 1—166; KEDVES, 1979, Acta Miner.-Petr. Szeged 24, 167—186; KEDVES, 1980, Acta Biol. Szeged 26, 63—77; KEDVES, 1983, Grana 22, 39—49; KEDVES, 1984a, Acta Biol. Szeged 30, 75—89, KEDVES, 1984b, Rev. Esp. de Micropaléont. 16, 43—50; KEDVES, 1985a, Acta Biol. Szeged 31, 97—113; KEDVES, 1985b, Rev. Esp. de Micropaléont. 17, 333—346; KEDVES, 1986, Rev. Esp. de Micropaléont. 18, 5—26; KEDVES — DINIZ, 1980—81, Bol. Soc. Geol. de Portugal 22, 19—32; KEDVES — ENDRÉDI, 1965, Acta. Biol. Szeged 11, 229—231; KEDVES — ENDRÉDI, 1968, Acta. Biol. Szeged 14, 11—18; KEDVES — HENGREEN, 1980, Pollen et Spores 22, 483—544; KEDVES — RÁKOSY, 1965, Acta Biol. Szeged 11, 51—53; KEDVES — RÁKOSY, 1967, Acta Biol. Szeged 13, 15—18; KEDVES — RUSSELL, 1982, Palaeontographica B, 182, 87—150; KEDVES — SIMONCSICS, 1978, Acta bot. Hung. 24, 69—89; KEDVES — ZSIVIN, 1970, Acta Biol. Szeged 16, 55—69; KLAUS, 1955, Verh. Geol. Bundesanst. 4, 239—242; KLAUS, 1956, Verh. Geol. Bundesanst. 3, 250—255; KONDRATIEV, 1973, The Palynology of Cenophytic, 16—17; KONZALOVÁ — STUCHLIK, 1983, Cas. miner. geol. 28, 363—378; KORALLOVA, 1962, Ukr. Bot. J. 19, 55—62; KORALLOVA, 1964, Izv. geol. 5, 138—140; KORALLOVA, 1966a, Ukr. min. Bull., 82—85; KORALLOVA, 1966b, Importance of palynological analysis for stratigraphy and paleofloristic, 141—145; KORALLOVA, 1968, Abstr., 1—16; KORALLOVA, 1971, Problems of Palynology, 129—143; KORENEVA, 1976, Palynology of the URSS, 103—104; KORENEVA, ZAKLINSKAYA, BRATSEVA — KARTASHOVA, 1966, Initial Reports of the Deep Sea Drilling Project 38, 1169—1193; KRIVÁN-HUTTER, 1961, Földtani Közlöny 91, 32—43; KRUTZSCH, 1966, Abh. zentr. geol. Inst. 8, 79—111; KRUTZSCH, PCHALEK — SPIEGLER, 1960, Internat. Geol. Congr. XXI Sess. 6, 135—143; KRUTZSCH — VANHOORNE, 1977, Palaeontographica B, 163, 1—110; KULKOVA, For the III. Internat. Palynol. Conf., 7—21; KULKOVA, 1973a, Nauka, 1—114; KULKOVA, 1973b, The Palynology of Cenophytic, 105—109; KULKOVA — LAUKHIN, 1975, Nauka, 1—88; KUNERT — LENK, 1964, Geologie 13, 403—428; KUPRIYANOVA, 1962, Acad. Sci. URSS, 28, 81—109; KUPRIYANOVA, 1965, Nauka; KUSNETZOVA, 1964, Bull. Kazakh. fil. of the URSS, Geol. Sci. 10, 1—165; KUSNETZOVA, 1965, Pollen et Spores 7, 535—538; KUSNETZOVA, 1966, Bull. Acad. Sci. URSS 168, 1135—1137; KUSNETZOVA, 1968, Paleopalynological Method for Stratigraphy, 166—174; KUSNETZOVA, 1970, Bull. Acad. Sci. URSS 190, 169—172; KUSNETZOVA, 1973a, The Palynology of Cenophytic, 55—60; KUSNETZOVA, 1973b, Bull. Geol. Inst. 35, 183—189; KUSNETZOVA, 1974, Bull. Acad. Sci. URSS, 215, 417—419; KUYL, MULLER — WATERBOLK, 1955, Geol. en Mijnbouw 17, 49—92; LATREILLE — MEON-VILAIN, 1966, Trav. Lab. Géol. Fac. Sci. Lyon N.S. 13, 7—18; LEFFINGWELL, 1971, Geol. Soc. of America, Spec. Paper 127, 1—64; LEIE, 1973, Palynology of Kazakhstan, 60—64; LEOPOLD — MACGINITIE, 1972, Elsevier Publ. Co., 147—199; LOHRENGEL II, 1969, Brighan Young Univ., Geol. Stud. 16, 61—186; MAÁCZ — SIMONCSICS, 1956, Acta Biol. Szeged 2, 51—58; MACGINITIE, 1974, Univ. Calif. Ann. Publ. Geol. Sci. 108, 48—66; MACKO, 1957, Prace Wrocl. Tow. Nauk. 88, 1—313; MACKO, 1959, Prace Wrocl. Tow. Nauk. B, 96, 5—175; MACKO, 1961, The New Phytologist 60, 207—210; MAKULBEKOV — PONOMARENKO, 1971, Palynology of Kazakhstan, 66—74; MANYKIN, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 173—178; MANUM, 1962, Norsk Polarinstitutt 125, 1—127; MARTINEZ-HERNÁNDEZ — SANCHEZ, 1980, Univ. Mexico, Inst. Geol. Revista 4, 155—166; MAZANCOVÁ, 1960, Sbor. Ustr. Ust. Geol. 27, 159—203; MAZANCOVÁ, 1960b, Cas. pro. miner. a geol. 5, 265—274; MAY — TRAVERSE, 1973, Geoscience and Man 7, 57—64; MCINTYRE — NORRIS, 1966a, N.Z. Geol. Geophys. 9, 243—246; MCINTYRE — NORRIS, 1966b, N.Z. Geol. Geophys. 9, 247—250; MÉDUS, 1965, Pollen et Spores 7, 381—392; MÉDUS, 1975, Rev. Esp. de Micropaléont. 7, 113—126; MÉDUS, 1977, Géobios 10, 625—639; MEON-VILAIN, 1965, Doc. Lab. Géol. Fac. Sci. Lyon 9, 13—17; MEON-VILAIN, 1968, Eclogae Geologicae Helveticae 61, 435—457; MEON-VILAIN, 1971, Docum. Lab. Geol. Univ. Lyon, H.S., 61—78; MEON-VILAIN, 1972, Docum. Lab. Geol. Fac. Sci. Lyon 49, 151—156; MERKULOVA, 1966, Palynology of Siberia, 90—95; MILAKOVIC, 1958, Bull. Serv. Gol. et Géophys. de la R.P. de Serbie 15, 193—203; MITZUL, 1973, The Palynology of Cenophytic, 170—173; MOHR, 1984, Paleontographica B, 191, 29—133; MOHR — FEHNER, 1986, Berliner geowiss. Abh. 66, 381—419; NAGY, 1957, Földtani Közlöny 87, 320—324; NAGY, 1969, Ann. Inst. Geol. Publ. Hung. 52, 237—649; NAGY, 1973, The Palynology of Cenophytic, 162—165; NAGY, 1985, Geol. Hung. Ser. Pal.; NAGY — RÁKOSI, 1966, M.Á.F.I. évi jel. az 1964 évről, 265—283; NAKOMAN, 1966, Bull. of the Miner. Res. and Exploration Inst. of Turkey 67, 68—88; NICHOLS — TRAVERSE, 1971, Geoscience and Man 3, 37—47; NORTON — HALL, 1969, Palaeon-

tographica B, 125, 1—65; OBERT — MEON-VILAIN, 1970, Docum. Lab. Geol. Fac. Sci. Lyon 37, 19—25; OLARU, 1970, Ann. Stiintice ale Univ. "Al. I. Cuza" din Iasi 16, 127—134; OLEINIK, 1971, Bull. Geol. Ministr. Tadzhik S.R. 4, 111—112; PACLTOVÁ, 1958, Cas pro miner. a geol. 3, 290—300; PACLTOVÁ, 1960, Sbor. Ustr. Ust. Geol. 25, 109—176; PACLTOVÁ, 1963, Sbor. Geol. Ved. paleontologie 2, 7—55; PACLTOVÁ, 1966, Roz. Ceskosl. Akad. Ved. 76, 1—68; PACLTOVÁ — SIMONCSICS, 1970, Paleobot. Abh. B, 3, 599—617; PAGHIDA-TRELEA, SIMIONESCU — OLARU, 1967, Ann. Stiint. ale Univ. "Al. I. Cuza" din Iasi 13, 83—99; PANOVA, 1968, Palaeopalynological Method for Stratigraphy, 206—219; PANOVA, 1971, For the III. Int. Palynol. Conf., 40—50; PASKEVICH, 1973, The Palynology of Pleistocene and Pliocene, 69—74; PENKOVA, 1973, The Palynology of Cenophytic, 165—170; PETERCÁKOVÁ-SNOPKOVÁ, 1983, Geol. Carpathica 34, 213—242; PETRESCU, 1973, The Palynology of Cenophytic, 132—138; PIEL, 1971, Canad. J. of Bot. 49, 1885—1920; PITTAU, 1977, Bol. della Soc. Paleont. Italiana 16, 3—14; PLANDEROVÁ, 1960, Geol. Prace 20, 183—188; PLANDEROVÁ — SNOPKOVÁ, 1960, Geol. Prace 19, 171—191; PLANDEROVÁ — SNOPKOVÁ, 1970, Geol. Prace 52, 301—343; POCKNALL — MILDENHALL, 1984, N.Z. Geol. Surv. Palaeont. Bull. 51; POGODAEVA — ORLOV, 1969, Palaeopalynological Method for Stratigraphy, 199—205; POKROVSKAYA — STELMAK, 1960, Leningrad; POLUMISKOVA, TEREKHOVA, BLYAKHOVA — PONOMARENKO, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 154—158; PONOMARENKO, 1966, Importannce of palynological analysis for stratigrphy and paleofloristic, 148—154; PORTNIAGINA, 1966, Importance of palynological analysis for stratigrphy and paleofloristic, 158—164; POTONIÉ, 1934, Arb. Inst. für Paläobotanik und Petrographie der Brennsteine 4, 25—125; POTONIÉ — VENITZ, 1934, Arb. Inst. für Paläobotanik und Petrographie der Brennsteine 5, 5—58; POTTER jr., 1966, Geobotany, 65—76; PULATOVA, 1973, The Palynology of Cenophytic, 114—117; RÁKOSI, 1966, M.Á.F.I. évi jel. az 1964 évről, 377—387; RÁKOSI, 1968, M.Á.F.I. évi jel. az 1966 évről, 83—94; RÁKOSI, 1973, M.Á.F.I. Évkönyve 55, 497—697; RAMISHVILI, 1969, Acad. Sci. URSS, 1—131; RAMISHVILI, 1976, Palynology of the URSS, 119—122; REIN, 1961, Meyniana 10, 160—166; REIN, 1962, Geol. Jb. 79, 677—684; ROCHE, 1968, Bull. Soc. belge Géol., Paléont., d'Hydrol. 76, 145—165; ROCHE, 1969, Bull. Soc. belge Géol., Paléont., d'Hydrol. 78, 131—146; ROCHE, 1972, Bull. Soc. belge Géol. Paléont., d'Hydrol. 81, 183—189; ROCHE, 1973a, Bull. Soc. belge Géol., Paléont., d'Hydrol. 82, 484—495; ROCHE, 1973b, Mém. Expl. Cartes Géol. et Min. de la Belgique 13, 1—138; ROCHE — SCHULER, 1976, Minist. des affaires économiques, administration des Mines, Services geologiques de Belgique, Prof. Paper 11, 1—57; ROTMAN, 1971, Problems of Palynology, 117—123; ROTMAN, 1973, The Palynology of Cenophytic, 47—52; ROUSE, HOPKINS jr. — PIEL, 1971, Geol. Soc. of America, Spec. Paper 127, 213—246; ROUSE — SRIVASTAVA, 1972, Canadian J. of Earth Sci. 9, 1163—1179; RYBAKOVA, 1973, Paleontol. Bull. 12, 142—147; SAH — DUTTA, 1967, The Palaeobotanist 16, 177—195; SAMUEL — SNOPKOVÁ, 1962, Geol. Prace 63, 69—84; SCHNABEL — DRAXLER, 1976, N. Jb. Geol. Paläont. Abh. 151, 325—357; SCHOLTZ, 1985, Ann. S. Afr. Mus. 95, 1—109; SCHRANK, 1984, Berliner geowiss. Abh. A, 50, 189—207; SCHULER — OLLIVIER-PIERRE, 1981, Sci. Géol. Bull. 34, 219—238; SCHUMACKER-LAMBRY — ROCHE, 1973, Ann. de la Soc. Géol. de Belgique 96, 413—433; SEMOCHKINA, 1973, The Palynology of Cenophytic 142—145; SHEKHINA, 1954, Bot. J. 11, 89—108; SHEKHINA, 1957, Ukr. Bot. J. 14, 36—43; SHEKHINA, 1958a, Ukr. Bot. J. 15, 61—70; SHEKHINA, 1958b, Ukr. Bot. J. 15, 54—59; SHEKHINA, 1962, For the First Internat. Palynol. Conf. (Tucson, USA), 126—130; SHEKHINA, 1964, Ukr. Bot. J. 21, 84—90; SHEKHINA, 1966, Importance of palynological analysis for stratigraphy and paleofloristic, 184—188; SHEKHINA, 1969, Ukr. Bot. J. 26, 39—47; SHEKHINA, 1971, Problems of Palynology, 149—162; SHIMADA, 1955, Saito Ho-on kai Museum Res. Bull. 24, 1—7; SHIMADA, 1957, Ecological Review 14, 265—266; SHIMADA, 1959, Ecological Review 15, 31—34; SINGH, 1965, The Paleobotanist 24, 1—12; SIMONCSICS, 1959, Acta Biol. Szeged 5, 181—199; SIMONCSICS, 1963, Grana Palynologica 4, 410—423; SIMONCSICS, 1969, Acta Biol. Szeged 15, 37—49; SNOPKOVÁ, 1966, Geol. Práce 20, 189—195; SNOPKOVÁ, 1980, Západné Karpaty, ser. paleont. 5, 7—74; SOHMA, 1958a, Ecological Review 14, 273—288; SOHMA, 1958b, Ecological Review 14, 289—290; SOHMA, 1958c, Ecological Review 14, 291—300; SOHMA 1959, Ecological Review 15, 9—12; SOLE DE PORTA, 1960, Bol. de geol. 4, 45—53; SOLE DE PORTA, 1972, Studia Geol. 4, 103—142; SOLE DE PORTA — DE PORTA, 1976, Cuad. Geol. 7, 53—55; SOLE DE PORTA — DE PORTA, 1977, Studia Geol. 13, 67—88; SOTNIKOVA, 1961a, Palynology of Kazakhstan, 126—131; SOTNIKOVA, 1971b, Palynology of Kazakhstan, 132—136; SRIVASTAVA, 1966, Pollen et Spores 8, 497—552; SRIVASTAVA, 1967, Palaeogeogr., Palaeoclimatol. Palaeoecol. 3, 122—150;

SRIVASTAVA, 1969, J. Sen Memorial Vol., 47—67; SRIVASTAVA, 1984, Palynology 8, 33—49; STANLEY, 1965, Bull. Amer. Paleont. 49, 179—384; STAPLIN, 1976, Bull. Canad. Petrol. Geol. 24, 117—136; STONE, 1973, Bull. Amer. Paleont. 64, 1—135; STOVER — PARTRIDGE, 1973, Royal Soc. of Victoria 85, 237—286; STOVER — PARTRIDGE, 1982, Palynology 6, 69—95; SUC, 1976, Rev. de Micropaléont. 18, 246—255; SUN XIUYU, ZHAO YINGNIANG — HE ZHOUSHENG, 1984, Geol. Rev. 30, 207—216; SUNG TZE-CHEN —TSAO LIU, 1978, Nanjing Inst. Geol. and Paleont., Acad. Sinica, 1—177; TAKAHASHI, 1973, The Palynology of Cenophytic, 12—16; TAKAHASHI, 1981, Bull. Fac. Lib. Arts, Nat. Sci. 22, 21—48; TAKAHASHI, 1982, Trans. Proc. Paleont. Soc. Japan 126, 303—326; TAKAHASHI — JUX, 1986, Bull. Fac. Lib. Arts, Nagasaki Univ., Nat. Sci. 26, 27—303; TEREKHOVA, 1971, Palynology of Kazakhstan, 137—140; THOMSON — PFLUG, 1953, Palaeontographica B, 94, 1—138; TRAVERSE, 1955, Bur. Min. Repts. Invest. 5151, 1—107; TREVISAN, 1967, Palaeontographica Italica 62, 1—73; TSCHUDY, 1973, Geol. Surv. Prof. Paper 770, 1—42; TSCHUDY, 1973, Geol. Surv. Prof. Paper 743—E, B1—B21; TSCHUDY — VAN LEONEN, 1970, Geol. Surv. Prof. Paper 643—E, 1—5; TSCHUDY — PATTERSON, 1975, J. Res. US Geol. Surv. 3, 437—445; VAKULENKO, 1961, Palynology and Biostratigraphy of the Soviet Arctic 124, 137—161; VAN DER HAMMEN — WIJMSTRA, 1964, Leidse Geol. Meded. 30, 183—241; VANHOORNE, 1973, Palynology of Pleistocene and Pliocene, 175—178; VENKATACHALA — BALTES, 1962, Petrol si Gaze 13, 241—288; VENKATACHALA — KAR, 1969, The Palaeobotanists 17, 157—178; VENOZHINSKIENE, 1960, XXI. Int. Geol. Congr., 247—252; VOLKOVA, 1971, For the III. Internat. Palynol. Conf., 61—93; WILLIAMS — BRIDEAUX, 1975, Geol. Surv. of Canada 236, 1—63; WINGATE, 1983, Palynology 7, 93—132; WOLFF, 1934, Arb. Inst. Paläobot. u. Petrogr. der Brennsteine 5, 55—88; ZAGWIJN, 1967, Rev. Palaeobot. Palynol. 2, 173—181; ZIEMBINSKA-TWORZYDLO, 1974, Acta Paleont. Polonica 19, 309—432; ZHEZHEL, 1973, Palynological Method for Stratigraphy 195, 180—184; ZHENG YA-HUI — ZHANG SHU-WEI, 1986, Acta Micropaleont. Sinica 3, 151—160; ZIVA, 1973, The Palynology of Cenophytic, 89—92; YU JING-XIAN, GUO ZHENGYNIG — MAO SHAOZHI, 1983, Prof. Papers Stratig. Palaeont. 10, 1—87.

References

ANANOVA, E.N. (1974): Pollen grains in the Neogene deposits of the southern Russian Plain. — Leningrad. (Russian).

BRENNER, G.J. (1976): Middle Cretaceous Floral Provinces and Early Migrations of Angiosperms. — Origin and Evolution of Angiosperms, 23—47.

COOKSON, I.C. (1947): Plant microfossils from the lignites of Kerguelen Archipelago. — B.A.N.Z. Antarctic Res. Expedition *2*, 127—142.

ELSIK, W.C. (1968): Palynology of a Paleocene Rockdale lignite Milam County, Texas, II. Morphology and Taxonomy (End.) — Pollen et Spores *10*, 599—664.

KEDVES,M. (1987): Paleophytogeography of the angiosperm pollen grains during the Upper Cretaceous and the Tertiary I. — Acta Biol. Szeged *33*, 35—47.

KRUTZSCH, W., PCHALEK, J. and SPIEGLER, D. (1960): Tieferes Paläozän (?Montien) in Westbrandenburg. — Internat. Geol. Congr. XXI Sess. *6*, 135—143.

KUPRIYANOVA, L.A. (1965): Palynology of amentiferous plants. — Nauka, Moscow—Leningrad. (Russian).

MÜRRIGER, F. und PFLUG, H. (1951): Über die Altersstellung der Braunkohle von Burghasungen etc. — Notizbl. Hess. L.-Amt Bodenforsch. *6*, 87—97.

POTONIÉ, R. (1934): Zur Mikrobotanik des eozänen Humodils des Geiseltals. — Arb. Inst. Palaobot. Petrogr. Brennsteine *4*, 25—125.

POTONIÉ, R. (1951): Revision stratigraphisch wichtiger Sporomorphen des mitteleuropäischen Tertiärs. — Palaeontographica B, *91*, 131—151.

POTONIÉ,R (1960): Synopsis der Gattungen der Sporae dispersae III. Teil: Nachträge Sporites, Fortsetzung Pollenites. Mit Generalregister zu Teil I—III. — Beih. Geol. Jb. *39*, 1—189.

ROUSE, G.E. (1962): Plant microfossils from the Burrard formation of western British Columbia. — Micropaleontology *8*, 187—218.

THIERGART, F. (1937): Die Pollenflora der Niederlausitzer Braunkohle, besonders im Profil der Grube Marga bei Seftenberg. — Jb. preuss. geol. L.-A. *58*, 282—351.

THOMSON, P.W. und PFLUG, H.D. (1953): Pollen und Sporen des mitteleuropäischen Tertiärs. — Palaeontographica B, *94*, 1—138.

VAN DER HAMMEN, TH. (1956): A palynological systematic nomenclature. — Bol. geol. *4*, 63—101.

VAN DER HAMMEN, TH. and WIJMSTRA, T.A. (1964): A palynological study on the Tertiary and Upper Cretaceous of British Guiana. — Leidse Geol. Meded. *30*, 183—241.

WODEHOUSE, R.P. (1933): Tertiary pollen. II. The oil shales of the Eocene Green River Formation. — Bull. Torrey Bot. Club *60*, 479—524,

ACTA BIOL. SZEGED. 34. PP. 59—69 (1988)

DEGRADATION OF THE SPORODERM UNDER NATURAL AND IN VITRO CONDITIONS

M. KEDVES

Department of Botany, Attila József University, H—6701 Szeged, P.O.B. 657, Hungary

(Received: August 15, 1987)

Abstract

This paper survey the most important fields of researches concerning the biopolymer organization of the sporoderm and the up-to-date results.

Key words: spore-pollen wall, biopolymer organization

Remark. — This contribution was presented at the XIV. International Botanical Congress (Berlin West, 1987).

The investigation of the very resistant material of the spore-pollen wall has been the subject of many publications.

The 1st problem: **Studies of the monomers of the sporopollenin.**

Among the comprehensive publications of the early concepts, the work of TOMSOVIC (1960) is worth of mentioning. In this paper on the chemistry, it was established, that sporopollenin is a high-polymerized terpene derivate, similar to the cutin. ROWLEY and PRIJANTO (1977) reviewed the early concepts: a highly cross-linked lipid (FREY-WISSLING, 1953), a high molecular weight of polysaccharide (TRAVERSE, 1968). Several methods were also described. The results of SHAW and YEADON (1968), BROOKS and SHAW (1968, 1971, 1978) and SHAW (1971) fundamentally changed the first concepts. They established, that the precursors of the sporopollenin are β carotene, and oxidizing esters of carotenoids. The monograph, edited by BROOKS et al. (1971) on the concepts of the sporopollenin is very important. Some selected points from this very important monograph: Following POTONIÉ and REHNELT (1971) in the course of coalification the aliphatic part of the sporopollenin becomes more and more aromatised. This compound was named as sporin. On the basis of the results on the exine of recent Epacridaceae, FORD (1971) established the following; p. 131: "The mature pollen wall consists of three chemically and structurally distinct layers; the outermost ectexine is composed of sporopollenin, the endexine has a high lignin content while the intine is cellulosic." The following points are also very important: ROWLEY and SOUTHWORTH (1967) established, that the sporopollenin accumulates on unit membrane dimensions lamellae, and a paracrystalline molecular system may be presumed to be similar to the unit membrane. ROWLEY (1973) wrote: the wall itself is a molecular sieve. In 1975, ROWLEY pointed out, that the sporopollenin cannot any longer be considered as the only major component of the exine, for example lipopolysaccharides are embedded within it. ROWLEY et al. (1980) described the helical substructures of the exine. ROWLEY et al. (1981); Nonsporopolleninous macromolecules embedded within the

sporopollenin matrix of exines as glycocalyx units. SOUTHWORTH (1985, 1986) established that the exine material consists of three different solubilities in 2-amino-ethanol. A pentagonal polygon system was described.

The 2nd problem: **Degradation of the sporoderm during the sedimentation.**

This problem was studied also by several autors. Among the most important publications I cite KIRCHHEIMER (1933, 1935), HAVINGA (1963, 1967, 1984), HEINEN (1960, 1963), ELSIK (1966, 1968, 1971). The fact, that the taphonomical processus may aid in the discovery of the higher organized biopolymer units of the sporopollenin was observed first by KEDVES et al. (1974). Globular biopolymer units were described from the partially degraded exine of *Restioniidites hungaricus* (KDS. 1965) ELSIK 1968, and *Thomsonipollis magnificus* (PF. et TH. 1953) W. KR. 1960 from the Eocene sediments of Mississippi, USA. The same biopolymer units were described from both exines of the tropical grass (*Restioniidites,* Plate I, fig. 1), and from the probably dicotyledonous early angiosperm; Paranormapolles; *Thomsonipollis* (Plate I, fig.2). Recently, KEDVES and WINTER (in print) restudied the first pictures, and the pentagonal polygon substructures are well shown on these pictures too. These substructures were not recognized, and interpreted at the first observations.

On the partially degraded wall of an algal cyst - *Pleurozonaria concinna* — from the carbonate manganese ore layers of Urkut, Hungary, two types of biopolymer units were described. Small, globular particles (Plate I, fig. 3), and helical structures (Plate I, fig. 4) from the organic remnants, which are outer from the algal cysts. These are probably from very degraded pollen grains. Taking into consideration, that the manganese ore layers of Urkut are rich in *Classopollis* pollen grains, the new results of ROWLEY and SRIVASTAVA (1986) on the higher organized exine components of this pollen grain are very important.

The 3rd problem: **Degradation with *Helix* enzyme method.**

This method was elaborated for the preparation of the protoplasts for microbial genetics experiments. A monograph concerning this problem was published by PEBERDY and FERENCZY (1985).

3.1. Among the recent taxa *Corylus avellana* L., and *Taxus baccata* L. was the subject of our first experiments. *Corylus avellana* L. (KEDVES, 1986b); 16 different procedures were used. The most important results are as follows; p. 59: "*Helix* enzyme with merkapto-ethanol is suitable for the destruction of the ectexine. In this

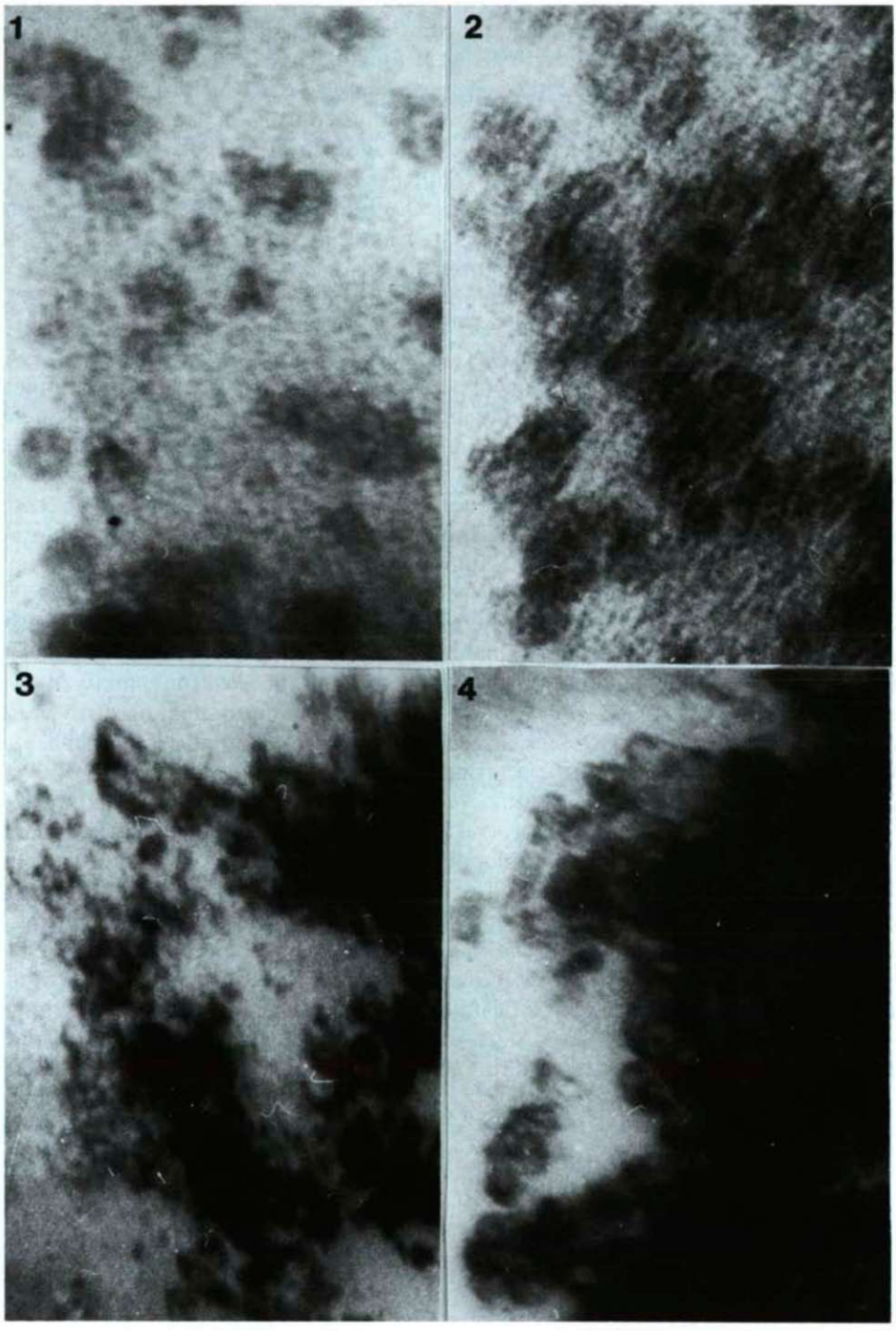
Plate I

1. *Restioniidites hungaricus* (KDS. 1965) ELSIK 1968, Mississippi, Eocene, 76/4, 68-618-17, x500000, following KEDVES et. al. 1974.

2. *Thomsonipollis magnificus* (PF. et TH. 1953) W. KR. 1960, Mississippi, Eocene, 74/3, 68-618-8, x500000, following KEDVES et al. 1974.

3. *Pleurozonaria concinna* (COOKSON and MANUM 1960) MÄDLER 1968, Urkut, Jurassic, 85/6, x250000, following KEDVES 1987c.

4. *Pleurozonaria concinna* (COOKSON and MANUM 1960) MÄDLER 1968, Urkut, Jurassic, 85/6, x250000, following KEDVES 1987c.


1
2
3
4

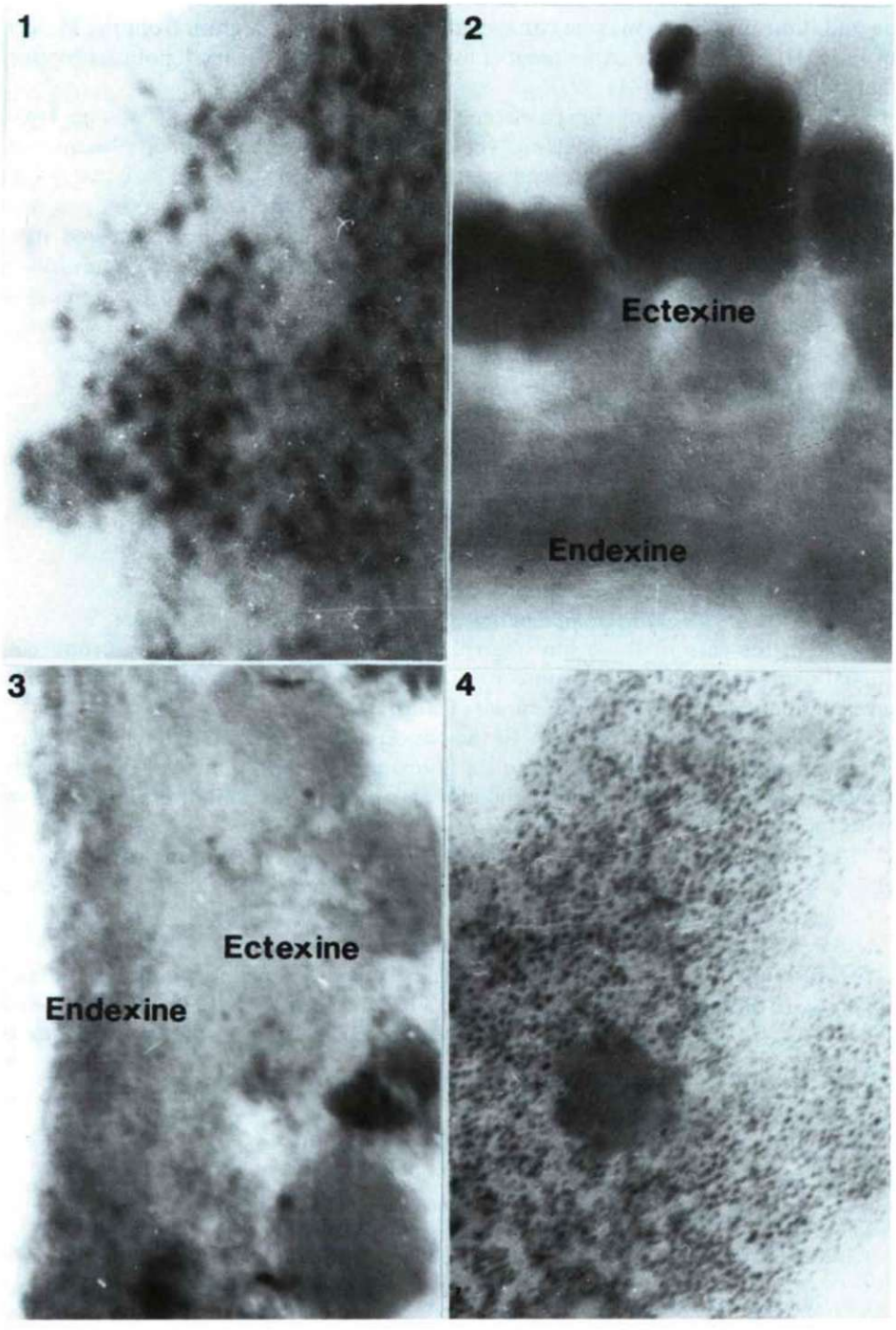
way, combined with the TEM method, the molecular structure of sporopollenin may be demonstrated". Globular units were found (Plate II, fig. 1). "Probably the basic elements are globular, and these elements may be arranged into units of higher order; filaments, helicoide structures, etc." "Because during all experiments there is the risk that the observed structures have been altered during the experiment or the preparation for the TEM investigations. Further experiments of different kinds are necessary on both recent and fossil biological objects before we can understand the details of the molecular structure of the sporopollenin. *Taxus baccata* L. (KEDVES 1987); The experimental degradations methods, which resulted at the exine of *Corylus avellana* L. in well defined globular biopolymer units, in the case of the *Taxus baccata* L. showed a different results. This means, that the chemical composition, and in consequence of this in the molecular structure of the exine of *Corylus* and *Taxus* there are essentially differences. In connection with this it is interesting to cite newly from the paper of UENO (1960) the following; p. 126/127: "The pigments were studied by SUITA (1948), KARRER and LEUMANN (1952) etc., and LUBLINER-MIANOWSKA (1955) investigated pigments in pollen grains of 67 species. According to him the pigments in pollen grains of conifers is not carotenoid, while that of entomophilous pollen of angiosperms is carotenoid." But BROOKS (1971) established the following; p. 351: "The chemical study of various modern and fossil spore walls of gymnosperms, angiosperms, pteridosperms fungi and algae show a majority to be composed of sporopollenin." It is interesting, that the merkapto-ethanol changed the electron affinity of the two principal layers of the exine of *Taxus baccata* L. The exclusive use of the merkapto-ethanol resulted that the electron affinity of the ectexine alternate stronger (Plate II, fig. 2). The merkapto-ethanol, with *Helix* enzyme caused an opposing effect, so that the electron affinity of the endexine became stronger than that of the ectexine (Plate II, fig.3).

3.2 Microfossils.

Botryococcus braunii KÜTZ (KEDVES 1986a) from the oil shale of the Pliocene layers of Pula, Hungary. Globular biopolymer units were described, but on our pictures published earlier on the plate III, the higher organized pentagonal polygon biopolymer structures are well shown (Plate II, fig. 4), similarly to the previously mentioned fossil taxa and of *Corylus avellana* L. It is important to emphasize, that the merkapto-ethanol only reveals the previously mentioned higher organized biopolymer system. In connection of this paper, it was pointed out, that the degradation is complex. The first steps starts during the sedimentation - taphonomical processus — and continued later during the experiments. Naturally, the two kind of

Plate II

1. *Corylus avellana* L. recent, experiment: C-2A, following KEDVES 1986b, x500000.
2. *Taxus baccata* L. recent, experiment: T-4b2, following KEDVES 1986d, x100000.
3. *Taxus baccata* L. recent, experiment: T-11A, following KEDVES 1986d, x100000.
4. *Botryococcus braunii* KÜTZ., Pula, Pliocene, experiment: B.4a.2, following KEDVES 1986a, x100000.


1
2
Ectexine
Endexine
3
Ectexine
Endexine
4

degradations processus may be connected. *Picea* type pollen grain from the Pliocene of Pula, Hungary. These experiments have not shown well defined globular biopolymer units (Plate III, fig. 1).

Palynomorphs from the Paleocene sediments of Menat, France. The Upper Thanetian sediments of Menat are very useful for these experiments because the richness of the very well preserved sporomorphs. In this case the only merkapto-ethanol was used, without *Helix* enzyme. Several types of sporomorphs were studied, but untill now the results have not been elaborated or discussed in all details. The preliminary results as it was presented at the APLE Symposium at Salamanca in the last year (1986c) are as follows: The most important groups of pollen grains, which were the subject of investigations:

1. Saccate gymnosperm pollen grains, *Pinus* type
2. Angiosperms, Longaxones
   Monocolpates
   Tricolpates
   Tricolporates

Among the Brevaxones, the following genera:

Plicapollis
Stephanoporopollenites
Platycaryapollenites
Triporopollenites

a) In the case of these sporomorphs, the merkapto-ethanol only produced a partial degradation of the sporomorphs. In several exines the globular higher organized biopolymer units are well shown (Plate III, fig. 2).

b) These results add support to the concept that there are differences between the gymnosperm and angiosperm pollen grains in the point of view of the molecular structure of the exines. In general the globular biopolymer units were not observed at the saccate gymnosperm pollen grains (Plate III, fig. 3).

c) The measure of the degradation of the different types of angiosperm pollen grains is uneven, but at this moment we have not enough data for general conclusions.

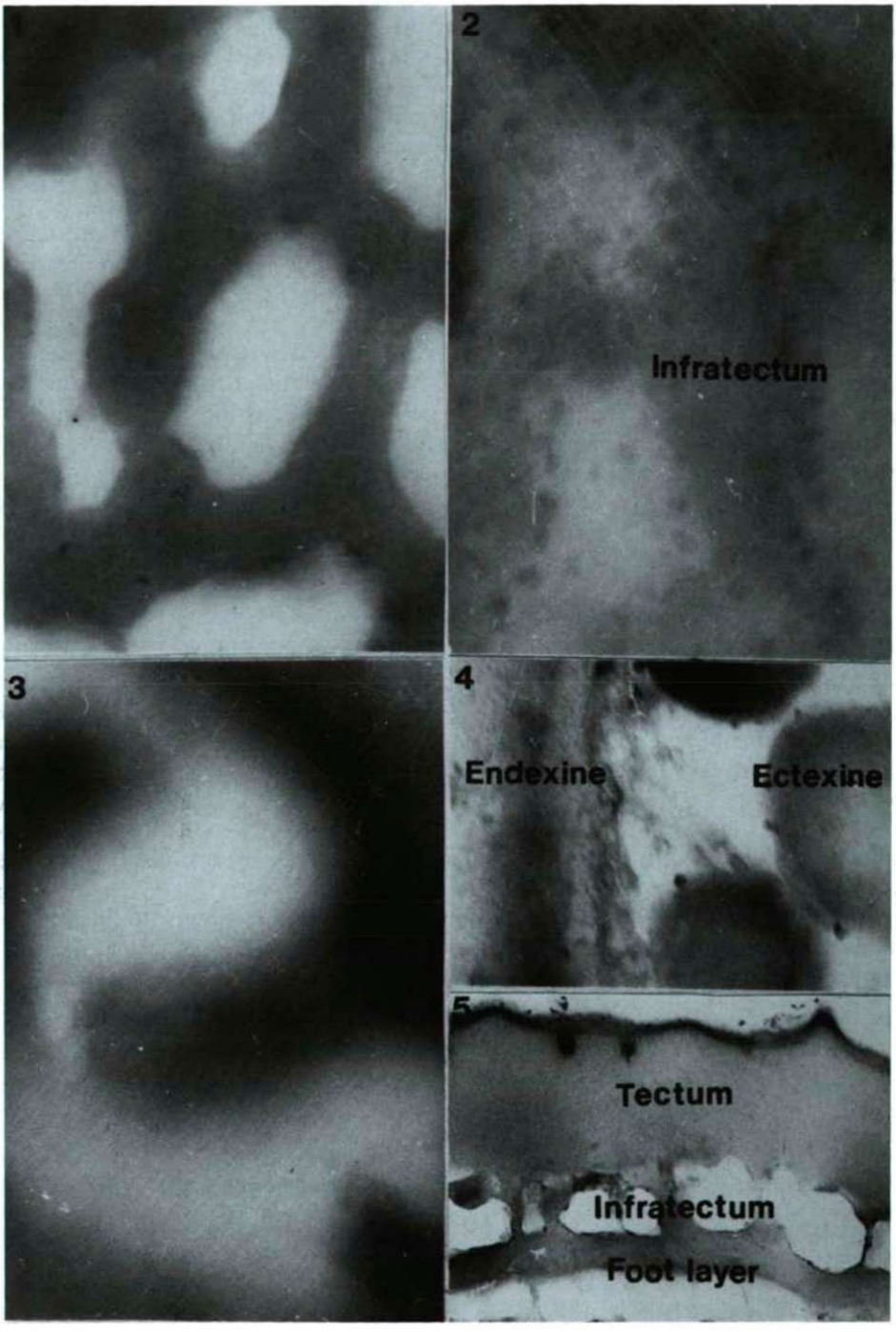
The 4th problem: **Degradation with solvent methods.**

More than 120 experiment was carried out. As starting point the classical solvents (BAILEY, 1960, SOUTHWORTH, 1985, DENIZOT, 1978, ROWLEY and PRIJANTO, 1977, ROWLEY, et al., 1981) were used. Our up-to-date results may be summarize as follows:

1. It is interesting, that the benzine, methanol, and ethanol degraded the

Plate III

1. *Picea* type, Pula, Pliocene, experiment: B.1.2., x100000.
2. *Cupuliferoipollenites pusillus* (R. POT. 1934) R. POT. 1960, Menat, Paleocene, 85/58, x250000.
3. *Pityosporites,* type *haploxylon,* Menat, Paleocene, 85/45, x250000.
4. *Taxus baccata* L. recent, x100000.
5. *Corylus avellana* L. recent, x50000.


2
Infratectum
3
4
Endexine
Ectexine
5
Tectum
Infratectum
Foot layer

lamellar ultrastructure of the endexine of the pollen grains of *Taxus baccata* L. (Plate III, fig. 4). These solvents produced a narrow layer with very strong electron affinity in the tectum of the pollen grains of *Corylus avellana* L. (Plate III, fig. 5).

2. Potassium permanganate aq. dil. degraded the wall of *Botryococcus braunii* KÜTZ. Globular biopolymer units, and pentagonal polygon substructures were observed (Plate IV, fig. 1).

3.1. 2-aminoethanol combined with oxydation of potassium permanganate resulted to pentagonal polygon subunits in the fossil algue *Botryococcus* from the oil shale of Pula Hungary (Plate IV, fig. 3) this is similar to the previous experiments. Rarely lamellar biopolymer organization was observed (Plate IV, fig. 2).

3.2. Recent species

Equisetum arvense L., with J. WINTER. — Globular subunits were observed, arranged in pentagonal polygons in the elateres, the globular forms of the surface, perispore and exospore. The perispore (Plate IV, fig. 4) and the globular forms on the perispore are more resistant than the exospore (Plate IV, fig. 5).

3.3 These experiments strongly degraded the ectexine, in this case the endexine was also more resistant (Plate IV, fig. 6—8).

Conclusions

1. By the different methods of degradation the results and conclusions may be the same — *Botryococcus* from the oil shale, or may be different, for example the *Corylus* and *Taxus* — experiments with *Helix* enzyme method and with degradation of 2-aminoethanol and potassium permanganate.

2. It seems, that the results of all experiments must be taken seriously and are useful.

3. According to the previous results, e.g.: SOUTHWORTH (1985, 1986) by the solubility of the exine by 2-aminoethanol the degrees of organization of the sporoderm may be reconstructed.

4. The pentagonal polygon biopolymer organization seems to be in this moment a general structure. See *Botryococcus, Equisetum, Taxus, Abies, Corylus,* among the fossil angiosperms *Restioniidites, Thomsonipollis.*

Plate IV

1. *Botryococcus braunii* KÜTZ., Pula, Pliocene, 20 mg. air dried material + $KMnO_4$ aq. dil. 4%, length of time: $2^h30'$, x500000.

2,3. *Botryococcus braunii* KÜTZ., Pula, Pliocene, experiment: 56, x500000.

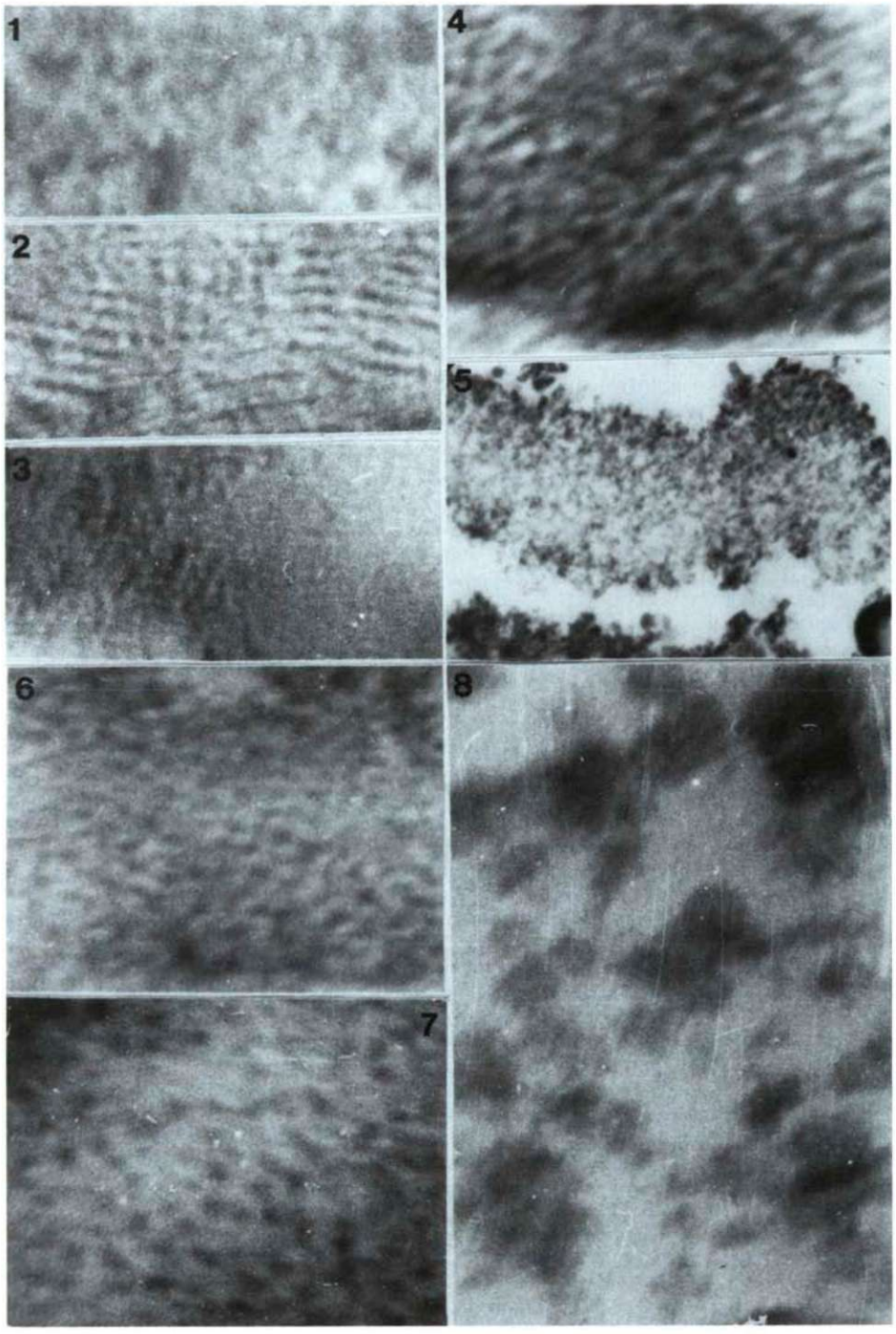
4. *Equisetum arvense* L. perispore, experiment: 73, x500000, following KEDVES and WINTER, in print.

5 *Equisetum arvense* L. exospore, experiment: 73, x50000, following KEDVES and WINTER, in print.

6. *Taxus baccata* L., recent, endexine, experiment. 54, x500000, following KEDVES 1987b.

7. *Abies concolor* HOOPES, recent, tectum, experiment: 81, x500000.

8. *Corylus avellana* L. recent, tectum experiment: 52, x500000.


1
2
3
4
5
6
7
8

5. The higher organizations of the sporopollenin may be important with regard to an evolutionary point of view. These structures may be:

lamellar
granular
globular
helical, etc.

6. Further methodical studies are also necessaries not only on the spore and pollen wall, but on the other kind of cell walls.

References

BAILEY, I. W. (1960): Some useful techniques in the study and interpretation of pollen morphology. — J. Arnold Arbor. Harv. Univ. *41*, 141—148.

BROOKS, J., GRANT, P.R., MUIR, M., VAN GIJZEL, P. and SHAW, G. (1971): Sporopollenin. — Academic Press, London, New York.

BROOKS, J. and SHAW, G. (1968): The post-tetrad ontogeny of the pollen wall and the chemical structure of the sporopollenin of *Lilium henryi*. — Grana Palynol. *8*, 227—234.

BROOKS, J. and SHAW, G. (1978): Sporopollenin: a review of its chemistry, palaeochemistry and geochemistry. — Grana *17*, 91—97.

DENIZOT, J. (1978): Au sujet de la solubilité de l'exine dans l'éthanolamine.—Ann. des Mines de Belgique *2*, 143—151.

ELSIK, W.C. (1966): Biologic degradation of fossil pollen grains and spore. — Micropaleontology *12*, 515—518.

ELSIK, W.C. (1968): Palynology of a Paleocene Rockdale Lignite, Milam County, Texas. I. Morphology and Taxonomy. — Pollen et Spores *10*, 263—314.

ELSIK, W.C. (1971): Microbial degradation of sporopollenin. In: Sporopollenin (eds.: BROOKS, J., GRANT, P.R., MUIR, M., VAN GIJZEL, P. and SHAW, G.). Acad. Press, London — New York, 480—511.

FORD, J. (1971): Ultrastructural and chemical studies of pollen wall development in the Epacridaceae. In: Sporopollenin (eds.: BROOKS, J., GRANT, P.R., MUIR, M., VAN GIJZEL, P. and SHAW, G.). Acad. Press, London — New York, 130—173.

FREY-WYSSLING, A. (1953): Submicroscopic morphology of protoplasm. Elsevier Publ. Co., Amsterdam.

HAVINGA, A.J. (1963): A palynological investigation of soil profiles developed in core sand. — Meded. Landbouwgeschool, *63*, 1.

HAVINGA, A.J. (1967): Palynology and pollen preservation. — Rev. Palaebot., Palynol. *2*, 81—98.

HAVINGA, A.J. (1984): A 20—year experimental investigation into the differential corrosion susceptibility of pollen and spores in various soil types. — Pollen et Spores *26*, 541—558.

HEINEN, W. (1960): Über den enzymatischen Cutin-Abbau; I. Mitt.: Nachweis eines "Cutinase"-Systems. — Acta bot. neerl. *9*, 167—190.

HEINEN, W. (1963): Über den enzymatischen Cutin-Abbau; V. Mitt.: Die Lyse von Peroxyd-Brücken im Cutin durch eine Peroxidase aus *Penicillium spinulosum* THOM. — Acta bot. neerl. *12*, 51—57.

KEDVES, M. (1965): A new Restionaceae pollen type from the Hungarian Lower Tertiary layers. — Advancing Frontiers of Plant Sciences *13*, 49—54.

KEDVES, M. (1986a): Dégradation expérimentale des colonies du genre Botryococcus des schistes pétroliféres du Tertiaire supérieur de Hongrie. — Acta Biol. Szeged *32*, 39—48.

KEDVES, M. (1986b): In vitro destruction of the exine of recent palynomorphs I. — Acta Biol. Szeged *32*, 49—60.

KEDVES, M. (1986c): Dégradation expérimentale de la paroi pollinique. — VI Simp. de Palinol., Salamanca, 20.

KEDVES, M. (1987a): Degradation of the sporoderm under natural and in vitro conditions. — XIV. Int. Bot. Congr. Berlin (West), Abstr., 295.

KEDVES, M. (1987b): Higher organized sporopollenin biopolymer structures and the explosion of the pollen grains under scanning effect. — Acta Biol. Szeged *33*, 163—165.

KEDVES, M. (1987c): Molecular structures from the organic remnants of the carbonate manganese ore layers of the III. Shaft of Urkut, Hungary. — Acta Biol. Szeged *33*, 57—62.

KEDVES, M. (1987d): In vitro destruction of the exine of recent palynomorphs II. — Acta Biol. Szeged *33*, 49—56.

KEDVES, M., STANLEY, E.A. and ROJIK, I. (1974): Observations nouvelles sur l'ectexine des pollens fossiles des Angiospermes de l'Eocéne inférieur. — Pollen et Spores *16*, 425—437.

KEDVES, M. and WINTER, J. (in print): Higher organized sporoderm biopolymer units of *Equisetum arvense* L. — Acta bot.

KIRCHHEIMER, F: (1933): Die Erhaltung der Sporen und Pollenkörner in den Kohlen sowie ihre Veranderungen durch die Aufbereitung. — Bot. Arch. *35*, 134—187.

KIRCHHEIMER, F. (1935): Die Korrosion des Pollens. — Beih. bot. Zbl. *53*, 389—416.

KRUTZSCH, W. (1960): Über *Thomsonipollis magnificus* (TH. et PF. 1953) n. fgen. n. comb. und Bemerkungen zur regionalen Verbreitung einiger Pollengruppen im älteren Paläogen. — Freiberger Forschungshefte *86*, 54—65.

PEBERDY, J.F. and FERENCZY, L. (1985): Fungal Protoplasts. M. Dekker Inc., New York and Basel.

POTONIÉ, R. and REHNELT, K. (1971): On the aromatisation of sporin of carboniferous Lycopsids. In: Sporopollenin (eds. BROOKS, J., GRANT, P.R., MUIR, M., VAN GIJZEL, P. and SHAW, G.). Acad. Press, London — New York, 295—304.

ROWLEY, J.R. (1973): Translocation through the pollen wall. — J. Ultrastructure Research *44*, 449—450.

ROWLEY, J.R. (1975): Lipopolysaccharide embedded within the exine of pollen grains. — 33rd Ann. Proc. Electron Microscopy Soc. Amer., 572—573.

ROWLEY, J.R., DAHL, A.O. and ROWLEY, J.S. (1980): Coiled construction of exinous units in pollen of *Artemisia*. — 38th Ann. Proc. Electron Microscopy Soc. Amer., 252—253.

ROWLEY, J.R., DAHL, Å.O., SENGUPTA, S. and ROWLEY, J.S. (1981): A model of exine substructure based on dissection of pollen and spore exines. — Palynology *5*, 107—152.

ROWLEY, J.R. and SOUTHWORTH, D. (1967): Deposition of sporopollenin on lamellae of unit membrane dimensions. — Nature *213*, 703—704.

ROWLEY, J.R. and SRIVASTAVA, S.K. (1986): Fine structure of Classopollis exines. — Can. J. Bot. *64*, 3059—3074.

ROWLEY, J.R. and PRIJANTO, B. (1977): Selective destruction of the exine of pollen grains. — Geophytology *7*, 1—23.

SHAW, G. (1971): The chemistry of sporopollenin. In: Sporopollenin (eds: BROOKS, J., GRANT, P.R., MUIR, M., VAN GIJZEL, P. and SHAW, G.). Acad. Press, London — New York, 305—348.

SHAW, G. and YEADON, A. (1968): Chemical studies on the constitution of some pollen and spore membranes. — J. Chem. Soc. C, 16.

SOUTHWORTH, D. (1985): Pollen exine substructure. I. Lilium longiflorum. — Amer. J. Bot. *72*, 1274—1283.

SOUTHWORTH, D. (1986): Substructural organization of pollen exines. — Pollen and Spores: Form and Function, 61—69.

THOMSON, P.W. and PFLUG, H.D. (1953): Sporen und Pollen des mitteleuropäischen Tertiärs. — Palaeontographica B, 94, 1—138.

TOMSOVIC, P. (1960): Bemerkungen zum Feinbau Des Sporoderms und seiner Terminologie. — Preslia *32*, 163—173.

TRAVERSE, A. (1968): What is sporopollenin? — Amer. J. Bot. *55*, 722.

UENO, J. (1960): Studies on pollen grains of Gymnospermae. Concluding remarks to the relationship between Coniferae. — J. Inst. Polytechnics, Osaka City Univ. D, *11*, 109—136.

TRANSMISSION ELECTRON MICROSCOPICAL INVESTIGATION OF XYLEM REMAINS TRANSPORTING RADIOACTIVE ELEMENTS IN THE MUD OF LAKE VADKERT

M. KEDVES AND T. SZEDERKÉNYI

Department of Botany and Department of Mineralogy, Geochemistry and Petrology
Attila József University H—6701 Szeged, P.O.B. 654, 651, Hungary

(Received: March 20, 1987)

Abstract

Using transmission electron microscope method we have established the following: 1. The submicroscopic structure of the xylem remnants transporting radioactive elements reworked into the mud of Lake Vadkert may be studied in ultra-thin sections. 2. The ultrastructures of the xylem remnants is not the same in the different samples studied. This is the consequence of the different degree of coalification or the taphonomical process. The tendency of the change is towards the homogeneous coal without submicroscopic structure. 3. The lamellar ultrastructure, described from the secondary xylem of the recent taxa was in some places discernible. 4. There are granules with high electron density in the organic debris enclosing the xylem fragments.
Key words: Palynology, Xylotomy, ultrastructure.

Introduction

In the course of our complex investigations of the mud of Lake Vadkert (KEDVES and KÖRMÖCZI, 1985) we have mentioned that in the Holocene mud of the lake there are dark coloured xylem remnants, too. On the basis of our further investigations it was established that the mud of Lake Vadkert is radioactive (KEDVES and SZEDERKÉNYI, 1985), and the intensity of this radioactivity is twofold of the "usual". Among others we have pointed out the curative effect of the mud. Further, complementary and verificatory investigations were carried out of the mud of Szikssóstó (Dorozsma, Szeged) and some localities of the backwater of Tisza. Based on these results the transport of the radioactive elements is connected with the rebedded secondary xylem remnants. Referring to this problem here are two basics: SZALAY (1954), p. 310: "Laboratory experiments of the author revealed that decomposing plant debris, peat, lignite, and brown coal have a very high adsorption power and capacity for uranium, which is in fact sufficiently high to explain geochemical enrichement." BREGER, DEUL and RUBINSTEIN (1955), p. 226: "Uranium is not held in the coal by ion exchange but seems to be present in the form of organo-uranium compounds that are soluble at pH less than 2.18". From several point of view it was necessary to carry out detailed investigation of the secondary xylem remnants. The aim of the first investigation with transmission electron microscope was as follows:

1. Are the dark coloured and coalified secondary xylem remnants suitable for transmission EM investigation, e.g.: is it possible to prepare ultra-thin sections for this purpose?

2. When the TEM method is suitable for these xylem remnants, what kind of information can be obtained for the diagenetic process of the secondary wood on the basis of its ultrastructure?

Material and Methods

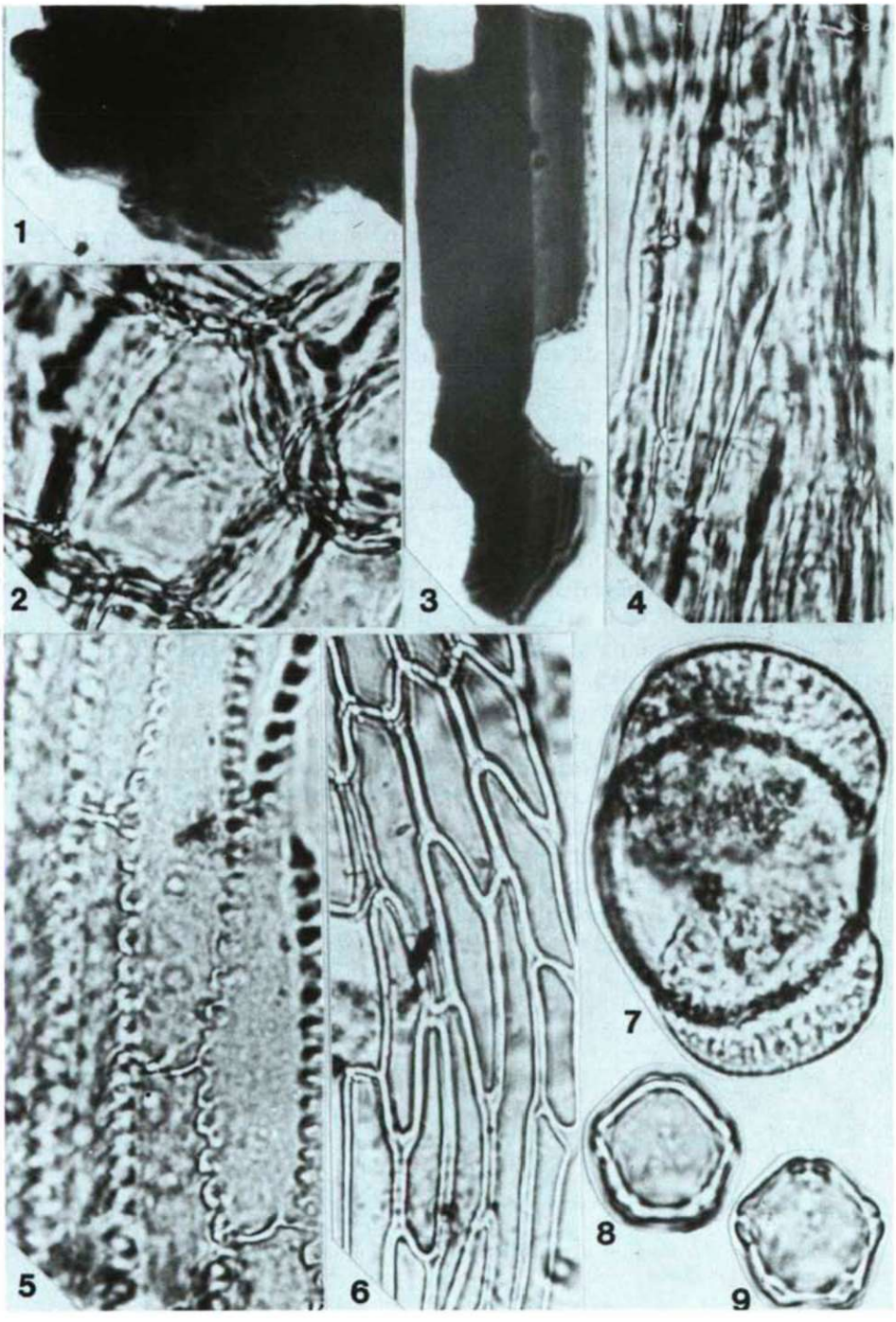
Altogether 10 xylem fragments were used for transmission electron microscopical investigations. Among them macroscopically six were stronger, four were in a less degree coalified. The method of the mud samples for microscopical plant remnants was published in a previous paper (KEDVES and KÖRMÖCZI, 1985). In this way, we mention the most important steps: HCl to eliminate carbonates and sulphides; $ZnCl_2$ solution density about 2 to separate organic matter from the inorganic HF to eliminate residous inorganic materials. After washing, postfixation with OsO_4 aq. dil., embedding in Araldite. The ultra-thin sections were made with glass kniwes in the EM Laboratory of the Biological Center of the Hungarian Academy of Science in Szeged, with an ultra-microtome of Porter Blum. The pictures were taken in the EM Laboratory of the J. A. University, on a Tesla B-500 electron-microscope, resolution 6 Å. We express our sincere thanks to Dr. I. ROJIK for his kind technical assistance, Among the xylem remnants investigated seven are from sample A/1, in which the colonies of the *Botryococcus* algue occur in predominant quantity. Among the pollen grains, *Phragmites* occur in the highest per cent, the more important of these: Cyperaceae, *Urtica, Allium* and Chenopodiaceae. Three secondary xylem remnants from mud sample No. II/4 were selected for TEM investigations. In consequence of the strong biological activity the plant microfossil remnants of this sample decomposed; pollen grains of the Cyperaceae occurred in the largest quantity (cf. KEDVES and KÖRMÖCZI, 1985, Fig. 2, p. 270). The geochemistry of the lignin derivates (cf. HATCHER et al., 1988) was not studied during our investigations.

Results

In the investigations with LM method, the dark coloured secondary xylem remnants (Plate I, fig. 1,3) can be well distinguished from the other Holocene plant tissue remnants (Plate I, fig. 2, 4—6), and from the pollen grains, respectively (Plate I, fig. 7—9). Among the Holocene tissue remnants there are parenchym (not lig-

Plate I

1—9. LM pictures from the microscopic plant remnants of the mud of Lake Vadkert.
1. Reworked secondary xylem fragment; prep. A/1-1; 11.4/141.7.
2. Holocene parenchym tissue remnant; prep. A/1-2; 11.5/142.4.
3. Reworked less coalified secondary xylem remnant; prep. A/1-1; 19.8/138.4.
4. Holocene tissue remnant with fibrous cells; prep. A/1-2; 16.3/142.8.
5. Holocene epidermis remnant of Gramineae type; prep. A/1-1; 17.5/140.8.
6. Holocene epidermis remnant of dicotyledonous type; prep. A/1-2; 18.5/144.8.
7. *Pinus* pollen; prep. A/1-2; 11.8/142.4.
8,9. *Alnus* pollen; prep. A/1-1; 11.9/139.8.
X1000


1
2
3
4
5
6
7
8
9

nified), (Plate I, fig. 2), prosenchyma (Plate I, fig. 4) and epidermis remnants (Plate I, fig. 5, 6), too. Among the dark coloured secondary xylem remnants, which transport the radioactive elements there are some where the vessel structure can be recognized, but several, in all probability because of the high degree of coalification are completely homogeneous. It is regrettable, but rebedded sporomorphs were not observed in the spore-pollen assemblages, what was very important in the determination of the geological age of the rebedded secondary xylem remnants.

With the transmission electron-microscope method the following may be established about the not strongly coalified secondary xylem remnants (Plate II, fig. 1—4 plate III, fig. 1, 2): The lamellar structure of the wall of the secondary xylem can be recognized of course with secondary alterations. Some of the lamellae are darker coloured; there are differences in the osmium affinity. The submicroscopic structure can be established in consequence of the taphonomic process, the preparation procedure, made possible in different degree to study the submicroscopic structure of the wall of the secondary xylem. These structures are in one respect in the dimension of the fibrils which are discernible with transmission electron-microscope (Plate II, fig. 1—4, plate III, fig. 1), on the other hand in the dimension of large biopolymer structures (Plate III, fig. 2).

On the basis of ultrastructure two types can be distinguished at the strongly coalified secondary xylem fragments (plate III, fig. 3, 4, plate IV, fig 1—3, plate V, fig. 1—3):

1. More or less compact remnants, their submicroscopic structure identical on the outher and the inner parts of the debris (Plate III, fig. 3, 4, plate IV, fig. 1, 2). The lamellar structure of the wall of the secondary xylem may be perceived only in some places. There are holes oriented towards the elements of the secondary xylem. In these fragments the fibrillar structure, wich is common at the not strongly coalified remnants occur only in some parts, and in a strongly dezorganized condition (Plate IV, fig. 2). Fibrills in the dimension of biopolymers were not detectable. On the xylem remnants there are organic debris, with well defined morphological features, some are electron dense material (Plate III, fig. 4, plate IV, fig. 1).

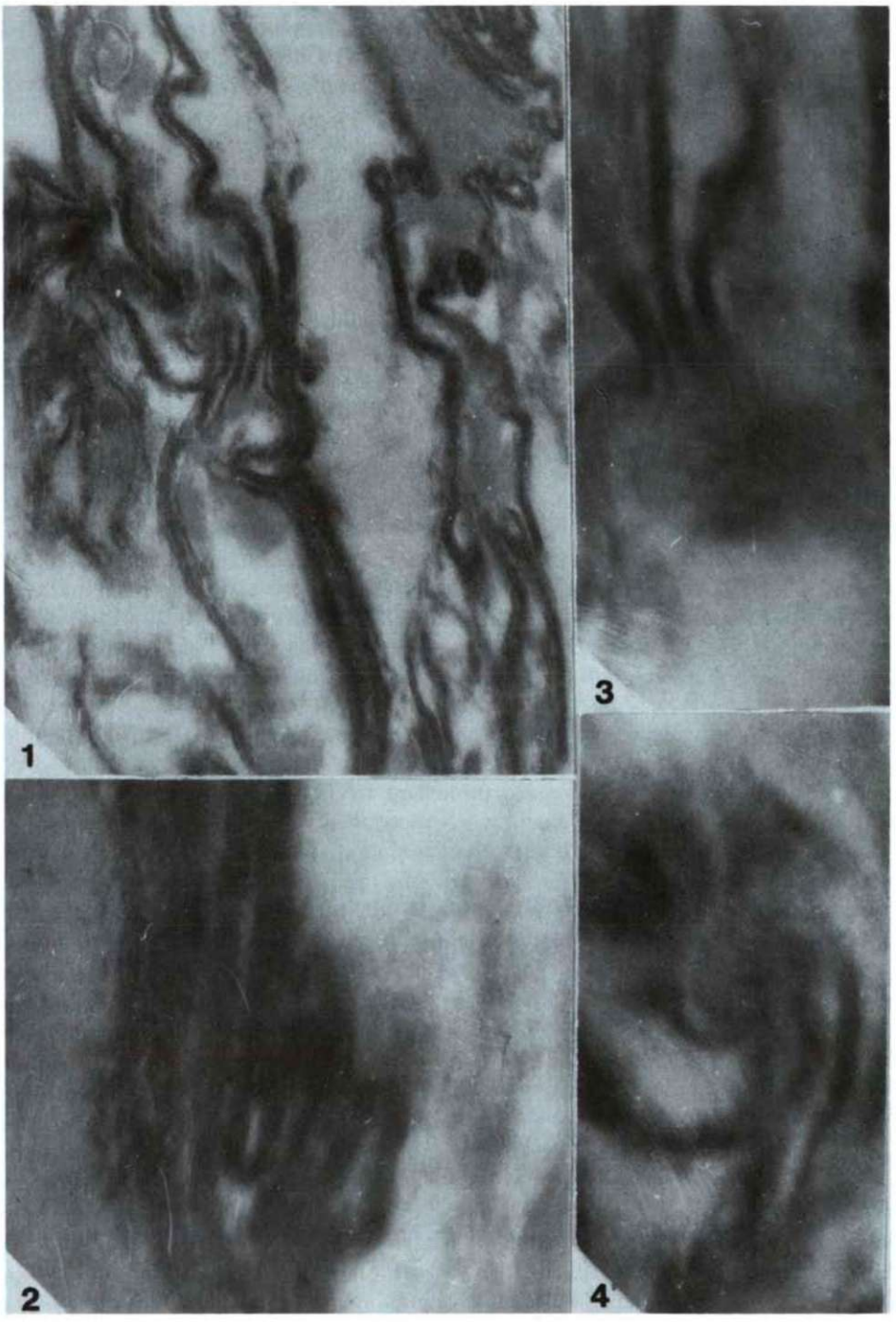
2. In the case of the second types the ultrastructure of the secondary xylem remnant differs on the outer and the inner part. The inner part is roughly indentical with the above-mentioned one, strongly coalified, and its consistence is compact. For the

Plate II

1-4. Transmission electron microscope pictures from less coalified reworked secondary xylem remnants.

1. General picture from the ultrastructure of the wall of the secondary xylem. Sample No: II-4; block-number: 86/19; x50000.

2-4. Ultrastructure of the fibrills. Sample No: II-4; block-number: 86/19; x150000.


1
2
3
4

outer part of the secondary xylem fragment a loose structure is characteristic, and in a degraded condition a fibrillar structure can be discernible (Plate IV, fig. 3, plate V, fig. 1, 2). In general, the fibrills are strongly degraded (Plate V, fig. 3).

Discussion

As regards the fine structure of the secondary xylem several results were published, with several conceptions. FREY—WISSLING (1957) emphasized that the ultrastructure of the secondary xylem is useful to solve taxonomic problems. KORÁN and CÔTÉ (1964) established that the ultrastructure of the tyloses is in connection with the mechanism of the growth. FREI et al. (1957) described the ultrastructure of the tracheids of the conifers. CHAFE (1974) in the thickened and primary wall of *Chamaecyparis nootkatensis* (D. DON.) SPACH. observed lamellar structure. PARAMESWARAN and LIESE (1978) in connection with the investigation of the bamboo established the following; p. 7: "Cross section of the wall thickening (w) of protoxylem element evidencing paralell arrangement of microfibrils." Concerning our own results the paper by HARCHE and CATESSON (1985) is particularly important, but it is important concerning all investigations of the xylem; p. 61: "Lignified secondary walls appear compact on ultra-thin sections and their texture is difficult to visualize without a prior extraction of matrix material." In this way the fact for itself that the secondary xylem fragments transporting reworked, coalified radioactive elements are suitable for transmission electron microscopical investigations can be taken as a result. We think it is important to point from the above cited authors the following; p. 61: "Methylamine alone was reported as a good, mild extractant of wood all walls (CZANINSKI et MONTIES, 1982 ROLAND et MOSINIAK, 1983)." The polylamellate structure published by HARCHE and CATESON (1985) was suitable for transmission electron microscopical investigations after the elimination of the polysaccharids. Essentially it is similar to the method of 2-aminoethanol and other solvents and oxidizing agents in the investigation of the biopolymer system of the sporoderm; cf. ROWLEY et al. 1981, SOUTHWORTH, 1974, 1985). The polylamellate structure observed by us (Plate III, fig 2) regarding its dimension and degree is essentially lower than those published in the data in several papers. In this

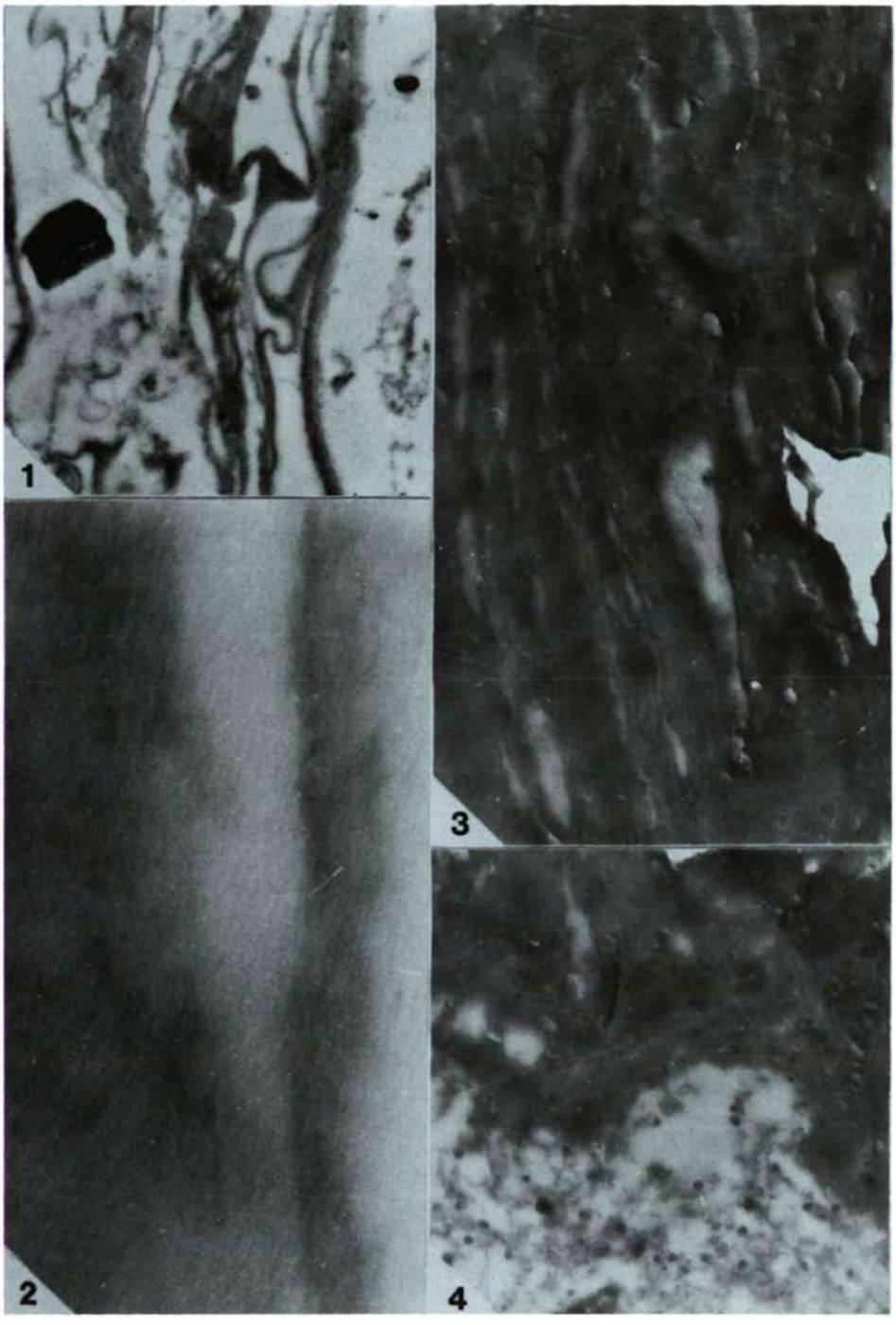
Plate III

1. General picture from the ultrastructure of a less coalified secondary xylem. Sample No: II-4, block number: 86/22; x10000.

2. Detail from the fibrillar structure of the wall of the secondary xylem. Sample No: II-4; block number: 86/22; x250000.

3. General picture from the ultrastructure of a coalified secondary xylem. Sample No: A/1, block number: 86/36; x10000.

4. Ultrastructure of the xylem remnant, and of the organic remnants of the embedding sediments. Sample No: A/1; block number: 86/36: x10000.


1
2
3
4

way during the sedimentation and the preparation method the investigated structure by TEM method was essentially the same as that of the secondary xylem of the recent taxa. In both cases some polysaccharids were degraded.

Using the transmission electron microscope method on fossil leave remnants BROWN et al. (1978) observed the microfibrillar structure of the cellulose. SMOOT and TAYLOR (1984) established essentially the same; p. 621: "The cell walls of sieve elements in the primary phloem of the Carboniferous fern *Tubicaulis* contain structural features that morphologically resemble cellulose microfibrils in extant plants." P. 622: "The presence of structurally identifiable but chemically altered fibrils in a fossil plant 290 million years old underscores the fidelity of morphological preservation in coal balls and suggests that it may be possible to use fossil material to investigate the evolution of such basic biological phenomena as the organization of cell wall constituents."

The phylogenetical significance of the biopolymer structures of the sporopollenin was pointed by KEDVES (1986) in connection with the degradation of the sporoderm. This molecular — biopolymer evolution may be extended to all remnants of living taxa containing organic materials.

Finally, in connection with the characteristic holes of the coalified secondary xylem remnants it can be noted that during the coalification and fossilization respectively gases may be formed also and this streched the fibrills of the secondary xylem. In this way the transmission electron microscope method can serve data in the solution of such problems.

References

BREGER, I.A., DEUL, M. and RUBINSTEIN, S. (1955): Geochemistry and mineralogy of on uraniferous lignite. — Economic Geology *50*, 206—226.

CHAFE, S.C. (1974): Cell wall thickenings in the ray parenchyma of yellow cypress. — IAWA Bull. *2*, 3—10.

CZANISKI, Y. et MONTIES, B. (1982): Étude cytologique ultrastructurale des parois du bois de Peuplier après extraction ménagée. — C.R. Acad. Sc. *295*, 551—556.

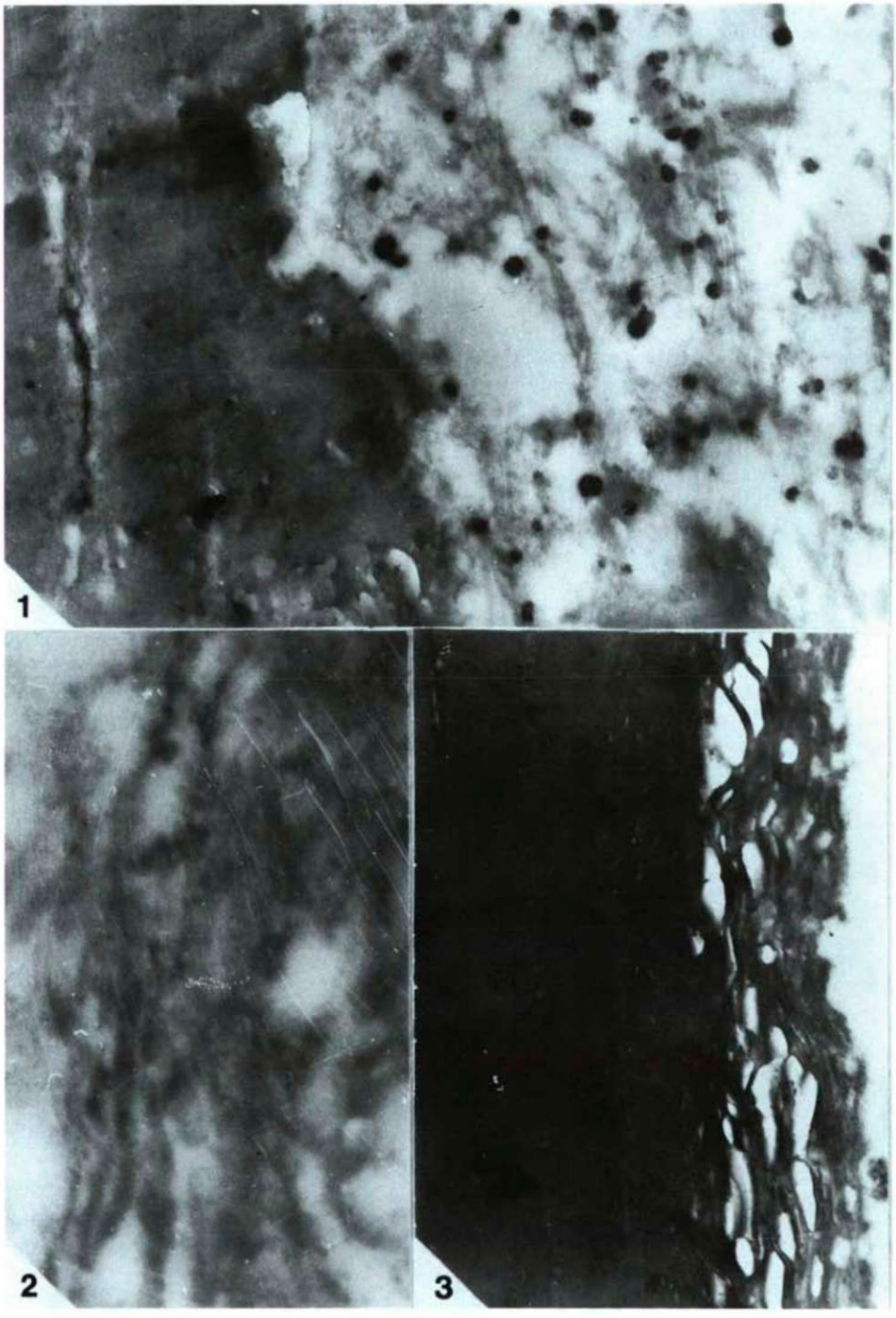
FREI, E., PRESTON, R.D. and RIPLEY, G.W. (1957): The fine structure of the walls of conifer tracheids. VI. Electron microscope investigation of sections. — J. Exp. Bot. *8*, 139—146.

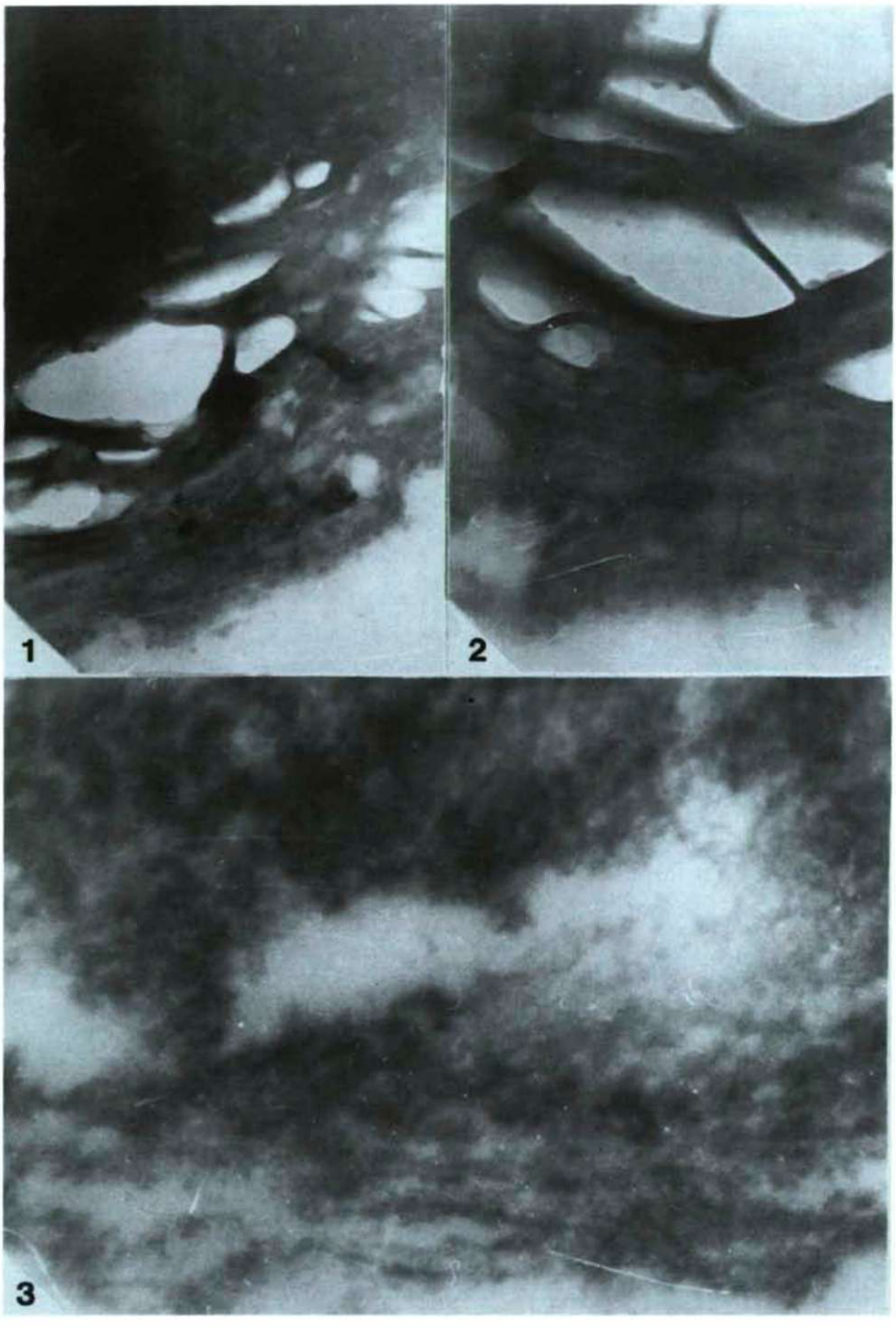
Plate IV

1. Ultrastructure of the secondary xylem remnant and of the organic remnants of the embedding sediment. Sample No: A/1; block number: 86/36; x25000.

2. Detail from the ultrastructure of the degraded fibrills. Sample No: A/1; block number: 86/36; x50000.

3. Ultrastructure of a coalified xylem remnant. The inner part is compact, the outer one is more loose. Sample No: A/1; block number 86/38; x25000.


1
2
3


1
2
3

FREY—WYSSLING, A. (1957): Use of the electron microscope in wood taxonomy. — IAWA News Bull. *1*, 1—4.

HARCHE, M. and CATESSON, A. M. (1985): Cell wall architecture in alfa (*Stipa tenacissima* L.) fibres. — IAWA Bull. n.s. *6*, 61—69.

HATCHER, P.G., LERCH III, H.E., VERHEYEN, T.V. and WILSON, M.A. (1988): Organic geochemical studies of the early coalification of peat and xylem tissue. — U.S. Geol. Surv. Circul. *1025*, 18—19.

KEDVES, M. (1986): Dégradation expérimentale de la paroi pollinique. — VI Simp. de Palinol. Resumenes, 20.

KEDVES, M. et KÖRMÖCZI, L. (1985): Sur les problèmes de conservation des sporomorphes dans des conditions différentes. — An. Asoc. Palinol. Leng. Esp. *2*, 263—271.

KEDVES, M. and SZEDERKÉNYI, T. (1985): The importance of the spore-pollen investigations in the recognition of the radioactive element of the lake mud. — Acta Biol. Szeged *31*, 215—216.

KEDVES, M. and SZEDERKÉNYI, T. (1986): Investigations on the microscopic plant remnants and the radioactive element content of some samples of the Hungarian Plain. — Acta Biol. Szeged *32*, 209—211.

KÓRÁN, Z. and COTÉ, W.A. (1964): Ultrastructure of tyloses and a theory of their growth mechanism. — IAWA News Bull. *2*, 3—15.

NIKLÁS, K.J., BROWN, R.M., SANTOS, R. and VIAN, B. (1978): Ultrastructure and cytochemistry of Miocene angiosperm leaf tissues. — Proc. nat. Acad. Sci. *75*, 3263—3267.

PARAMESWARAN, N. and LIESE, W. (1978). A note on the fine structure of protoxylem elements in bamboo. — IAWA Bull. *2—3*, 28—32.

ROLAND, J.C. and MOSINIAK, M. (1983): On the twisting pattern, texture and layering of the secondary cell walls of lime wood. Proposal of an unifying model. — IAWA Bull. n.s. *4*, 15—24.

ROWLEY, J.R., DAHL, A.O., SENGUPTA, S. and ROWLEY, J.S. (1981): A model of exine substructure based on dissection of pollen and spore exines. — Palynology *5*, 105—152.

SMOOT, E.L. and TAYLOR, T.N. (1984): The fine structure of fossil plant cell walls. — Science *225*, 621—623.

SOUTHWORTH, D. (1974): Solubility of pollen exines. — Amer. J. Bot. *61*, 36—44.

SOUTHWORTH, D. (1985): Pollen exine substructure. I. *Lilium longiflorum*. — Amer. J. Bot. *72*, 1274—1283.

SZALAY, S. (1954): The enrichement of uranium in some brown coals in Hungary. — Acta Geol. Acad. Sci. Hung. *2*, 299—311.

Plate V

1. Detail from the ultrastructure of the outer loose part of the carbonified secondary xylem remnant. Sample No: A/1; block number: 86/38; x50000.

2. The same detail with larger magnification. Sample No: A/1; block number: 86/38; x100000.

3. Degraded fibrills. Sample No: A/1; block number: 86/38; x100000.

ACTA BIOL. SZEGED. 34. PP. 83—95 (1988)

THE VEGETATION MAP OF THE SZÍVÓS-SZÉK UNESCO BIOSPHERE RESERVE CORE AREA, KISKUNSÁG NATIONAL PARK, HUNGARY

I. BAGI

Department of Botany, Attila József University, H—6701 Szeged, P.O. B. 657, Hungary

(Received: July 30, 1987)

Abstract

The paper comprises the vegetation map, to a scale of 1:5000, of the Szívós-szék UNESCO biosphere reserve core area and a short description of the distinguished vegetation units.

The dominant association of the territory is the *Agrostio-Caricetum distantis* (RAPCS. 27) SOÓ 30.Most of the core area is covered by subassociations and facies of this community adapted to the different hydro- and haloecological conditions. At the deepest reliefs, there are *Scirpo-Phragmitetum* KOCH 26, *Puccinellietum limosae* (RAPCS. 27) SOÓ 30 associations, as well as *Bolboschoenetum maritimi continentale* SOÓ (27) 57 on the lake bed. In smaller patches there are *Brometum tectorum* SOÓ (25) 39, BOJKO 34 and *Lepidio-Puccinellietum* (RAPCS. 27) SOÓ 57 associations.

28 vegetational units have been destinguished on the vegetation map. The nature protection problems of the core area have been mentioned also.

Key words: aerial photograph, biosphere reserve, halophilic vegetation, saline lake, vegetation mapping

Introduction

Szívós-szék (formerly Zsíros-szék) biosphere reserve core area is situated in the IV-th territory of the Kiskunság National Park. Its area is 68 hectares. It is one of those saline lakes which has emerged in a dip between the sandy dunes which consist of sand of Danubian origin (Fig. 1).

These lakes have an orientation in a NW — SE direction due to the most frequent NW direction of the wind. The shape of the Szívós-szék differs from that of other lakes. Already at the time of its emergence, several parallel dune lines were probably crevassed, and this presumably caused the recent shape of the lake. However, the orientation of the small lakes have been isolated from the main lake in a NW—SE direction.

The lake emerged in the Holocene period. It has been proved that the water-impermeable carbonate mud layer was not sedimented directly to the loess of Würm3 glacial, but onto a fine-grained sandy layer of postglacial origin and 2—6m thick (MOLNÁR and MURVAI, 1976). The terrestrial sedimentation in the Holocene can be studied in the works of MIHÁLTZ and FARAGÓ (1946), ZÓLYOMI (1953), MUCSI (1963), and JÁRAI—KOMLÓDI (1966;1969). The difference in the location of carbonate mud and the present situation of the lake bed shows that the extension and location of Szívós-szék had changed a lot from the time of emergence.

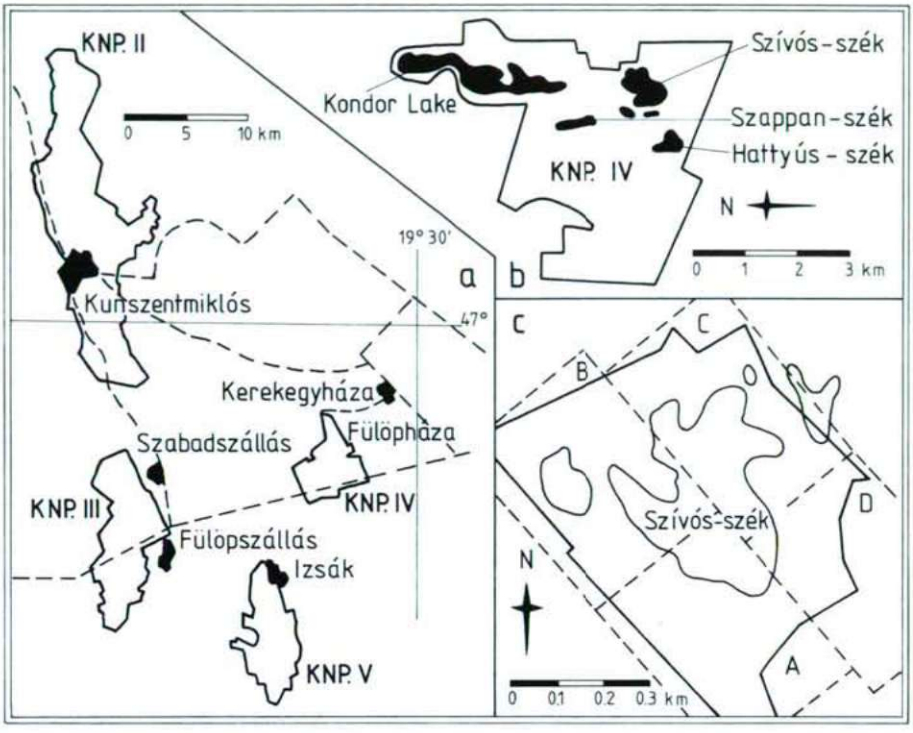


Fig. 1. Geographical location of the IV-th territory of the Kiskunság National Park (a) and the Szívós-szék biosphere reserve core area (b). The figure 'c' shows connection of the four map sheets (A,B,C,D).

The water management works implied a drastic interference in the life of lakes in our century.It led to a regional decrease of the water table, which is the water source of the lakes (ANDÓ, 1964). The direction and intensity of salt and water transport were considerably modified by the diking. Due to canalization, the water impervious carbonate mud layer has been damaged. Therefore, a large amount of water may escape (MOLNÁR, 1985).

The weather has an extreme influence on the water volume of the lakes. As a consequence of last years' dry weather period, such a rarely dry saline lake as Szappan-szék (next to Szívós-szék) dried out of late years. The decrease of the water level of Szívós-szék was especially drastic in the '60s. Therefore, in the last 10—15 years it usually dries out to towards the middle or end of summer. Due to the changes of salt conditions, by the end of the '70s the whole surface of Szívós-szék has become covered with *Bolboschoenus maritimus*.

The fast hydro- and haloecological changes caused a stormy transformation of the vegetation of the region. Hence, it is important to elaborate and documentate the present state of the vegetation of this UNESCO biosphere reserve core area. The first step of the work to be done is the preparation of a vegetation map.

Materials and Methods

The vegetation map has been prepared on the basis of a colour aerial photograph, the magnification of which close corresponds on a map to a scale of 1:5000. The method of vegetation mapping was similar to the one used in the Kisapaj core area (BAGI, 1987). The vegetation map shows the core area with its surrounding. The map is issued in the form of sheets joining without overlap. The four map sheets and their key are formally published as an appendix to this paper.

In the present paper the description of vegetation units is made with the assistance of the Zürich—Montpellier Phytosociology School. Nevertheless, the categorization of several transitional vegetation units — which has developed due to the intensive vegetational transformation processes — has hit against difficulties. The denomination of the species and cenosystematic units is according to the work of SOÓ (1964), though a significant part of the section describing the *Agrostio-Caricetum distantis* association is based on the cenosystematical results of BODROGKÖZY (1960; 1962a; 1962b).

The map was elaborated in 1987.

Results

The Szívós-szék UNESCO biosphere reserve core area and the mapped territories lie on soil deposited onto the terrestrial sediment of the former lake. Due to the water impermeability of carbonate mud, associations with high water demand have evolved. Fixed wind-blown sand covers only a little area of the mapped territory. Most of this is cultivated as plough-land, or orchard. A characterless *Brometum tectorum* association grows on the old fields. The forests and clumps of trees indicated also live on fixed wind-blown sand. The predominant trees are *Robinia pseudo-acacia* and *Populus alba*.

The majority of the mapped territory covered by the *Agrostio-Caricetum distantis* association and the subassociations and facies of this community have become adapted to the different hydro- and haloecological conditions. Coverages of 5—25% of *Carex distans* and of 15—30% of *Agrostis stolonifera* are characteristic for the typical (*agrostetosum* SOÓ) association. The cenological optima of the *Triglochin maritimum* and *Orchis palustris* fall into this vegetation unit. Towards the higher reliefs, the *Cynodon dactylon* forms a great extended facies with a transition through a series of grades. In this unit, less *Orchis palustris* can be found, and the *Triglochin maritimum* is extinct. At the same time, the *Linum perenne* forms a facies with a usual coverage of about 10%. The *Cynodon dactylon* has a coverage of 10—30%. The high cover degree of *Rhinanthus serotinus* ssp. *grandiflorus* is characteristic in the vegetation units mentioned. Its measure may be of a level of 25—30% in the *agrostetosum*.

The subassociation *festucetosum pseudovinae* of the *Agrostio-Caricetum distantis* develops on the higher terrains of the territory. The *Agrostis stolonifera* is extinct, the coverage of *Carex distans* decreasing to a measure of 1—5%. In typical cases, the coverages of *Festuca pseudovina* and *Cynodon dactylon* are 40—50% and 5—10%, respectively. The 10—25% coverage of *Achillea collina* is characteristic. Occurrence of the *Cynodon* facies of this subassociation is more frequent in this territory. This facies means a transition between the typical *Agrostio-Caricetum*

association and the *festucetosum pseudovinae* subassociation of this association. In the *Cynodon* facies of *festucetosum*, the coverage of *Festuca pseudovina* is from to 5—10% up to a maximum of 15%, whereas the *Cynodon dactylon* has a coverage of 40%. The *Linum perenne* is often another facies-forming species; in these cases, the coverage of *Cynodon* decreases. The unit of *Agrostio-Caricetum festucetosum pseudovinae Cynodon* facies was distinguished on the vegetation map. But it is important to emphasize: that the transition between every single subassociation and facies seems to be continuous. For example, the *Linum perenne* facies can not be distinguished on the map. A *Limonium gmelinii* variante can be relatively well separated from the *Agrostio-Caricetum festucetosum pseudovinae* subassociation. It develops on a soil which has turned into solonetz. Its physiognomic structure is similar to the *Artemisio-Festucetum pseudovinae* (MAGYAR 28) SOÓ (33) 45, wormwood saline plain association. It may also be regarded as a *limonietosum (staticetosum* BODRGK.) subassociation of *Artemisio-Festucetum.*

The *Lotus tenuis* facies of the *Agrostio-Caricetum distantis* association develops on the next deeper relief. The occurrence of *Alisma plantago-aquatica*, *Cirsium brachycephalum* and *Mentha aquatica* expresses the more hygrophilous character of the facies. On more binding soil — initially, in the lake beds isolated from the main lake — the same is indicated by the occurrence of *Scorsonera parviflora*, *Sonchus arvensis* and *Bolboschoenus maritimus*. The *Juncus compressus* near the *Lotus tenuis* is another facies-forming species. Its occurrence reveals a transition into the *Juncetum gerardii* WENDELBG. 50 association. The *Juncus compressus* forms stands on trampled places and on soils with a high salt content. It has a coverage of 30—40%, up to a maximum 70%.

By reason of antropogenic impacts — presumably too early mowing and moderate cattle grazing — the *festucetosum arundinaceae* subassociation of *Agrostio-Caricetum distantis* develops. Coverage of *Festuca arundinacea* may be 50%. The decrease of species diversity and the extinction of some floristically valueable species (*Orchis palustris*, *Orchis coriophora*, *Polygala comosa* and *Triglochin maritimum*) is detectable because it develops from the typical *Agrostio-Caricetum distantis*. The irrigation of meadows must be subordinate to environmental conservation.

The *asteretosum* subassociation of *Agrostio-Caricetum distantis* can be found on more binding soil on a small extension of the contact zone of the *Agrostio-Caricetum distantis* and the *Puccinellietum limosae* associations. It shows a similarity with the *Astero-Agrostietum* association, which is characteristic of heavy solonetz soils. Large stands can be found in the II-nd (saline lakes) territory of the Kiskunság National Park.

Phragmites australis facies of the *Agrostio-Caricetum distantis* association develop in place of the former *Scirpo-Phragmitetum* association due to a decrease of the water table. Its species spectrum is similar to the *Agrostio-Caricetum* association. The *Phragmites australis* occurs in the community like a consociation-forming species. These characteristics distinguish it from the *Scirpo-Phragmitetum asteretosum* unit, which has a species spectrum characteristic of the *Scirpo-*

Phragmitetum. The most important identical factor in the emergence of these units is the draining of the territory. The survival of the *Agrostio-Caricetum Phragmites* facies may be explained by the high degree of tolerance of *Phragmites australis* against the draining.

Towards the deeper reliefs the *Agrostio-Caricetum* associations are substituted, partly by the *Scirpo-Phragmitetum* association. This transition is shown by the *agrostietosum* subassociation of the latter. The characteristic *Phragmitetea* species refers to reeds: *Alisma plantago-aquatica, Cirsium brachycephalum, Lycopus europaeus* and *Lythrum salicaria*. The habitat of *Campanula sibirica* can be found in this vegetation unit. The *Scirpo-Phragmitetum asteretosum* subassociation develops in its most characteristic form in the isolated small lake beds. This unit continuously transforms into a typical *Scirpo-Phragmitetum* with the increase in water depth. The height of the common reed is close to 3 meters in its most beautiful stands.

In other places, the *Agrostio-Caricetum* is substituted by the *Puccinellietum limosae* association towards the deeper reliefs. In Szívós-szék, the stands of this community emerged as a result of anthropogenic impacts after the ploughing of the *Bolboschoenus* stands. The *Aster tripolium* (*asteretosum* subassociation) has a significant coverage (of up to 25%) in the external zones of the association. The typical *Puccinellietum limosae* stands are poor in species, the vegetation almost entirely consisting of *Puccinellia limosa*.

If the *Agrostio-Caricetum* association has a direct contacts with the *Bolboschoenus* stands developing on the lake bed, the *Agrostis stolonifera* and the *Bolboschoenus maritimus* form mixed stands — firstly in the NW part of the lake: the *Bolboschoenus Agrostis* complex in the map.

The deepest part of the lake is covered by the stands of the *Bolboschoenetum maritimi continentale* association. The height of the *Bolboschoenus maritimus* is a uniform 100—120 cm. At the end of summer, grass of *Crypsis aculeata* develops, accompanied by less *Chenopodium glaucum*. These stands of *Crypsidetum aculeatae* (BOJKO 32) TOPA 39 may be regarded as a grass layer of *Bolboschoenetum*. The stormy spread of *Bolboschoenus maritimus* is one of the most catastrophic problems of environmental conservation. Organic matter production of the *Bolboschoenus* stands is much higher then that of the *Crypsis* grass which formerly covered the lake bed. The occurrence of *Bolboschoenus* involves an extremely high degree of eutrophication. Its extirpation and the explanation of the cause of its spreading are very important tasks as regards nature protection.

Usually the lake bed is not separated with berms from the higher reliefs. But, if it does, then the layer of salt accumulation is deeper than the surface of the berm. There are only a few places where the layer of salt accumulation and the berm surface are at an identical level. Therefore, this circumstance makes possible the development of the *Lepidio-Puccinellietum limosae* association on solonchak soil developed in this way. The predominant species are the *Lepidium crassifolium* (10—15%) and the *Puccinellia limosa* (40—60%). Due to grazing, the *camphorosmetosum* subassociation of the *Lepidio-Puccinellietum limosae* develops.

Specific associations have emerged on the former bird islands which can now

be found covered in reeds. On the ornithogenic soil, partly ruderal *Sisymbrion officinalis* (cf. ELIÁS,1981) associations occur. Characteristic species are the *Descurainia sophia, Sisymbrium orientale, Urtica dioica, Sambucus nigra, Lactuca serriola, Chenopodium* and the *Atriplex* species.

A significant part of the mapped area is under sheep grazing (Fig. 2.). The *Agrostio-Caricetum* associations of these territories have been transformed to a large extent. On the lower reliefs, the vegetation of the typical association, its subassociations and its facies have a low coverage. The predominant new species is the *Trifolium fragiferum*. The high coverage of *Festuca pseudovina* (60—70%) and the occurrence of *Medicago lupulina* are characteristic of the subassociations and facies, which can be found on reliefs higher those where the typical *Agrostio-Caricetum distantis* is located. This is generally characteristic of territory under intensive grazing, low species diversity and the extinction of sensitive species.

Although the transitions usually occur between the vegetation units under grazing, and the drawing of every boundary is beyond the possibilities allowed by the scale of the map, some stands of antropogenic vegetational units were indicated on the map. The transitional stands between the *Agrostio-Caricetum festucetosum pseudovinae* and the *festucetosum arundinaceae* are caused by moderately intensive

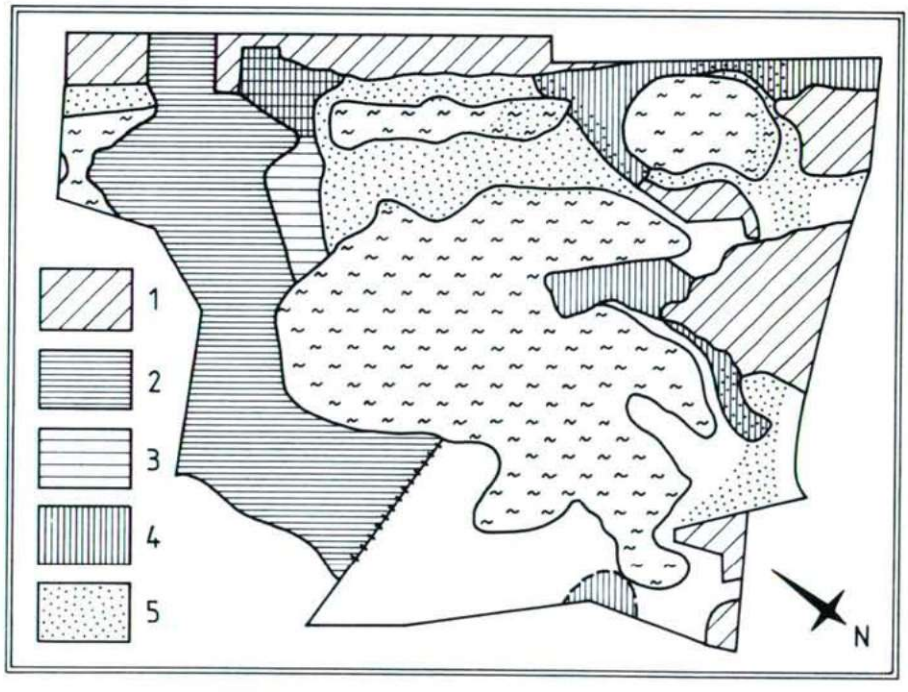


Fig. 2. Forms of economic utilization in the mapped area: 1. plough lands, orchards; 2. intensive sheep grazing; 3. moderate sheep grazing; 4. cattle grazing; 5. mowing in July.

grazing, similar to the development of *Agrostio-Caricetum Cynodon* facies and the *festucetosum arundinaceae* transition. Due to the intensive grazing, the stands of *Agrostio-Caricetum agrostietosum* (including its several facies) and *festucetosum* cannot be distinguished from each other. These transitional stands are categorized under the denomination: *Agrostio-Caricetum* x *festucetosum pseudovinae*.

The development of mosaic complexes between the *Agrostio-Caricetum Lotus* facies and the *Phragmites* facies, and also between the *Agrostio-Caricetum Lotus* facies and the *Cynodon* facies has been caused by continuous draining.

The description of the vegetation in the core area is given only to a degree necessary for interpretation and evaluation of the vegetation units indicated on the map. The ecological evaluation and the description of successional relations of vegetation will be subject of further investigation. The problems of environmental conservation were only touch upon here. A detailed description of these problems can be found in the Report of the Department of Botany of the Attila József University for the National Authority for Environmental Protection and Nature Conservation.

Acknowledgements

Thanks are due to Dr GY. BODROGKÖZY, reader at the Attila József University for his very useful cenological help. The author expresses his sincere thanks to the Directorate of the Kiskunság National Park — to Dr I. TÖLGYESI, Botanical Inspector, and Dr K. TÓTH, Director, for their generous help given in the course of these studies. This work was supported by the National Authority for Environmental Protection and Nature Conservation.

References

ANDÓ, M. (1964): Geomorphologische und hydrographische Characterisierung des Kunfehérsees und seiner Umgebung. — Acta Geographica Univ. Szeged. *5*, Fasc. 1—7.

BAGI, I. (1987): The vegetation map of the Kisapaj UNESCO biosphere reserve core area, Kiskunság National Park, Hungary. — Acta Biol. Szeged *33*, 63—74.

BODROGKÖZY, GY. (1960): Phytozönologische und bodenökologische Untersuchungen an den Sumpfwiesen im Süden des Gebietes Kiskunság (Klein-Kumanien). — Acta Bot. Hung. *6*, 171—207.

BODROGKÖZY, GY. (1962a): Ökologische Untersuchungen der Mähwiesen und Weiden der Mittel-Theiss. Das Leben der Tisza. XIII. — Phyton, Graz *9*, 196—216.

BODROGKÖZY, GY. (1962b): Die standortsökologischen Verhältnisse der halophilen Pflanzengeselschaften des Pannonicum. I. Untersuchungen an den Solontschak Szikböden der südlichen Kiskunság. — Acta Bot. Hung. *8*, 1—37.

ELIÁS, P. (1981): A short survey of the ruderal plant communities of western Slovakia. — Acta Bot. Hung. *27*, 335—349.

JÁRAI—KOMLÓDI, M. (1966): Adatok az Alföld negyedkori klima és vegetációtörténetéhez. I. (Quaternary climatic changes and vegetational history of the Great Hungarian Plain. I. In Hungarian with English summary). — Bot. Közlem. *53*, 191—201.

JÁRAI—KOMLÓDI, M. (1969): Adatok az Alföld negyedkori klima és vegetációtörténetéhez. II. (Quaternary climatic changes and vegetational history of the Great Hungarian Plain. II. In Hungarian with English summary). — Bot. Közlem. *56*, 43—55.

MIHÁLTZ, I. and FARAGÓ, M. (1946): A Duna—Tisza közi édesvizi mészképződmények (Carbonate formations of terrestrial sedimentation from the Danube—Tisza Interfluve. In Hungarian). — Alföld Tud. Int. Évk. *1*, 371—384.

MOLNÁR, B. (1985): Földtani kutatások a Kiskunsági Nemzeti Parkban (Geological Explorations in the Kiskunság National Park. In Hungarian with English summary). In Tudományos kutatások a Kiskunsági Nemzeti Parkban 1975—1984 (Research in Kiskunság National Park 1975—1984). (Ed.: TÓTH, K.). — Kiskunsági Nemzeti Park, Kecskemét, 29—58.

MOLNÁR, B. and MURVAI, I. (1976): A Kiskunsági Nemzeti Park fülöpházi szikes tavainak kialakulása és földtani története (Bildung und geologische Geschichte der Sodaseen Fülöpháza im Kiskunság National Park. In Hungarian with German summary). — Hidrológiai Közlöny *56*, 67—77.

MUCSI, M. (1963): Finomrétegtani vizsgálatok a kiskunsági édesvizi karbonátképződményekben (Studies on the fine stratification of the carbonate formation of the terrestrial sedimentation in Kiskunság region of Hungary. In Hungarian). — Földt. Közl. *93*, 373—386.

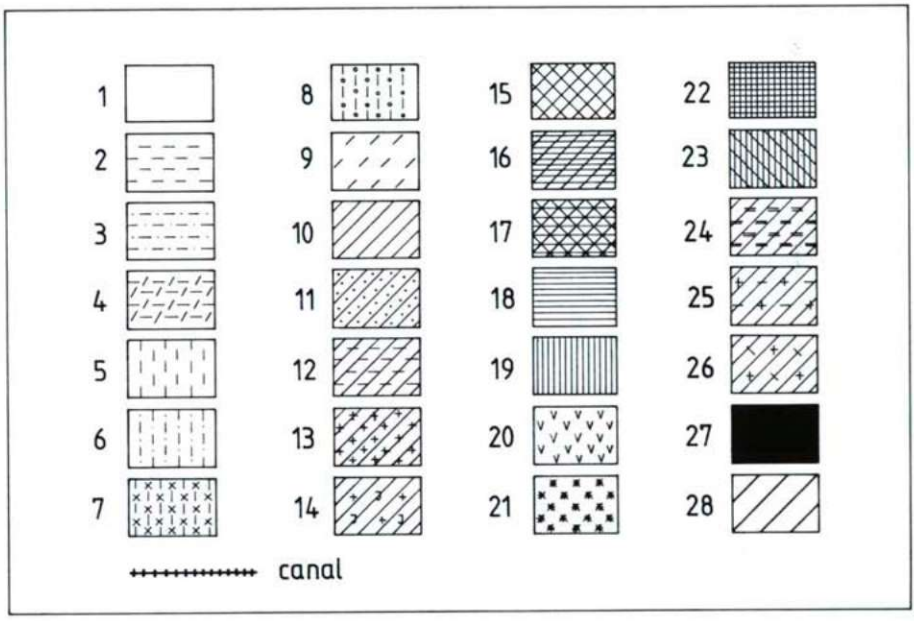
SOÓ, R. (1964): Synopsis systematico-geobotanica florae vegetationisque Hungariae I. — Akadémiai Kiadó, Budapest.

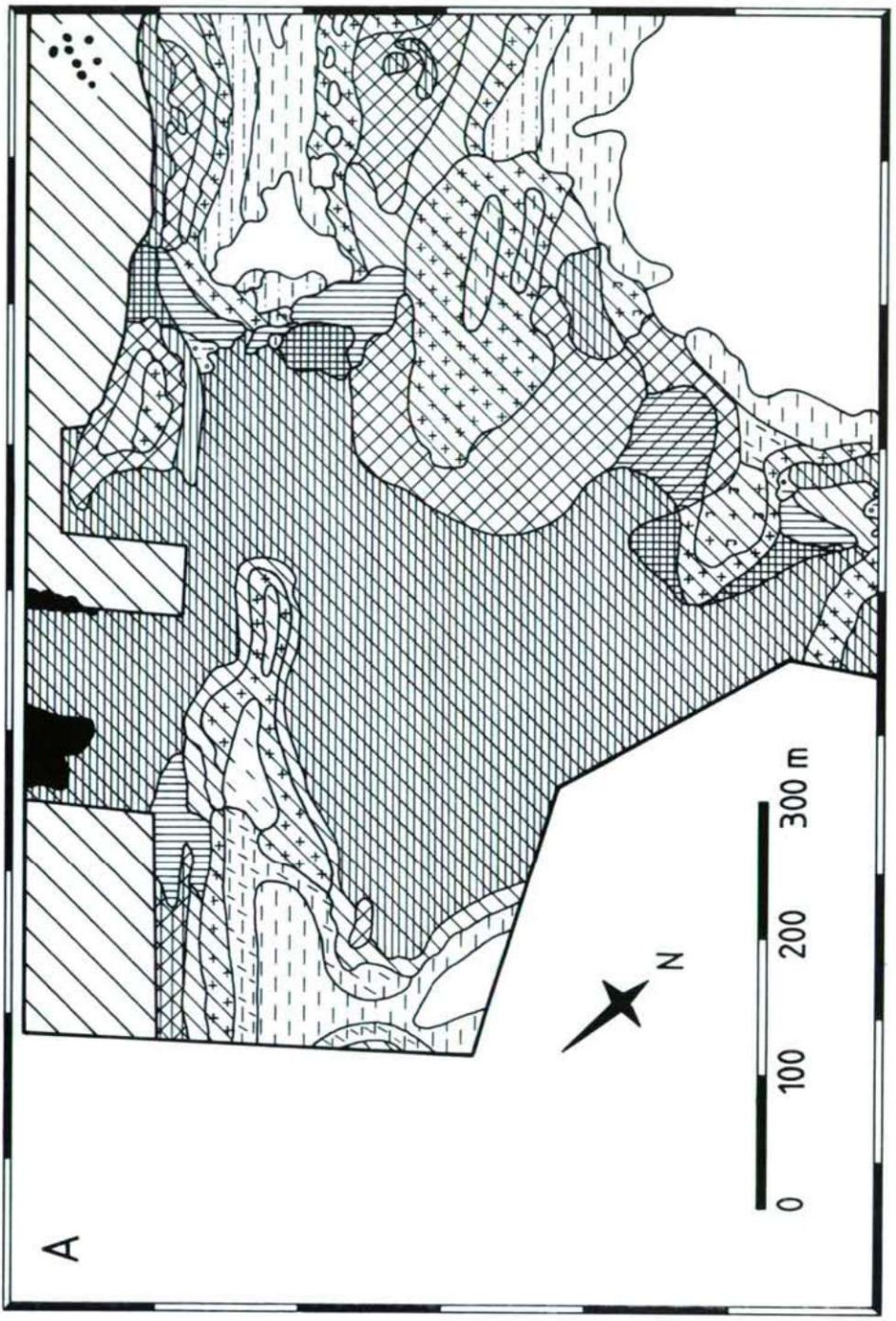
ZÓLYOMI, B. (1953): Die Entwicklungsgeschichte der vegetation Ungarns seit dem letzten Interglacial. — Acta Biol. Acad. Sci. Hung. *4*, 367—430.

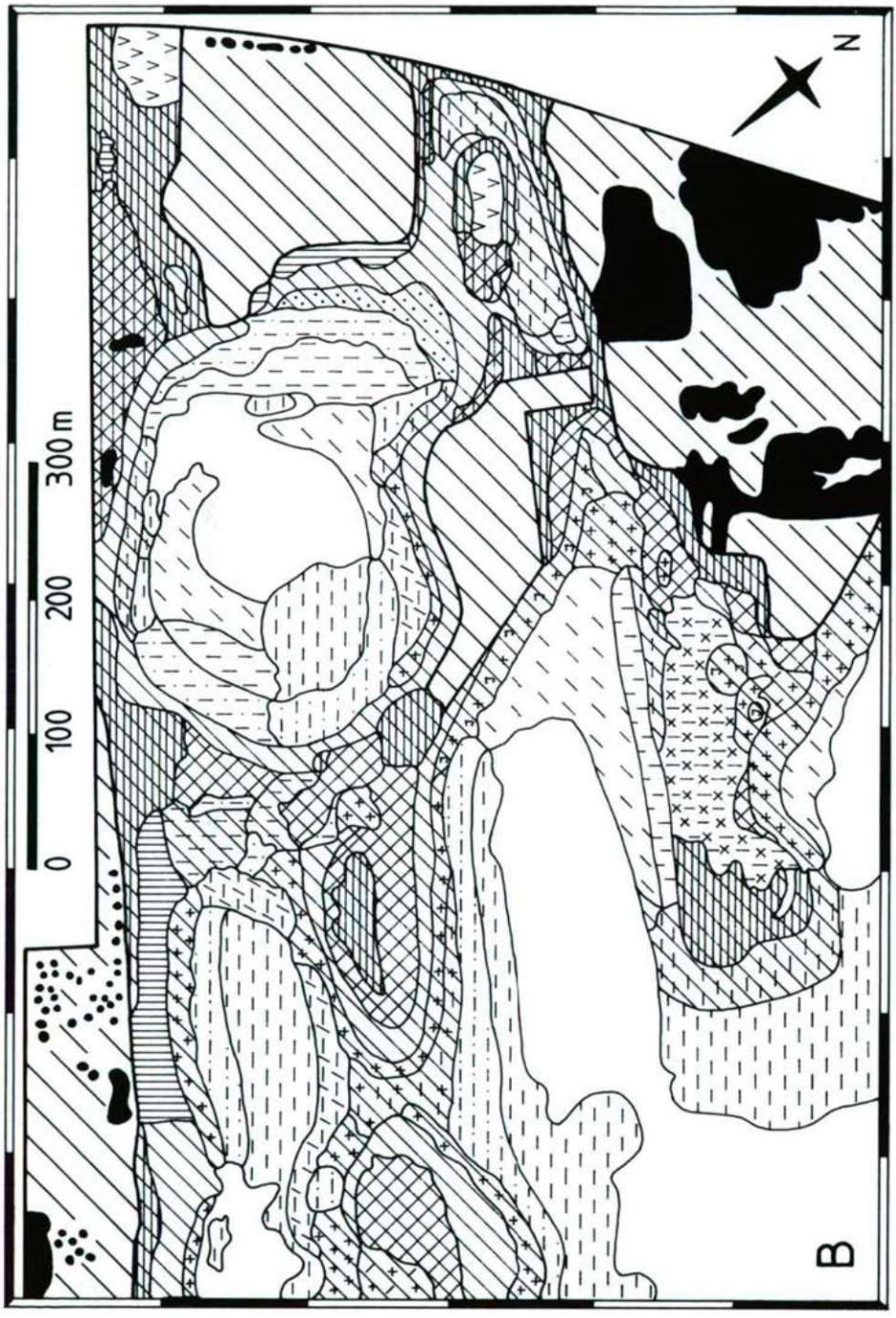
Appendix

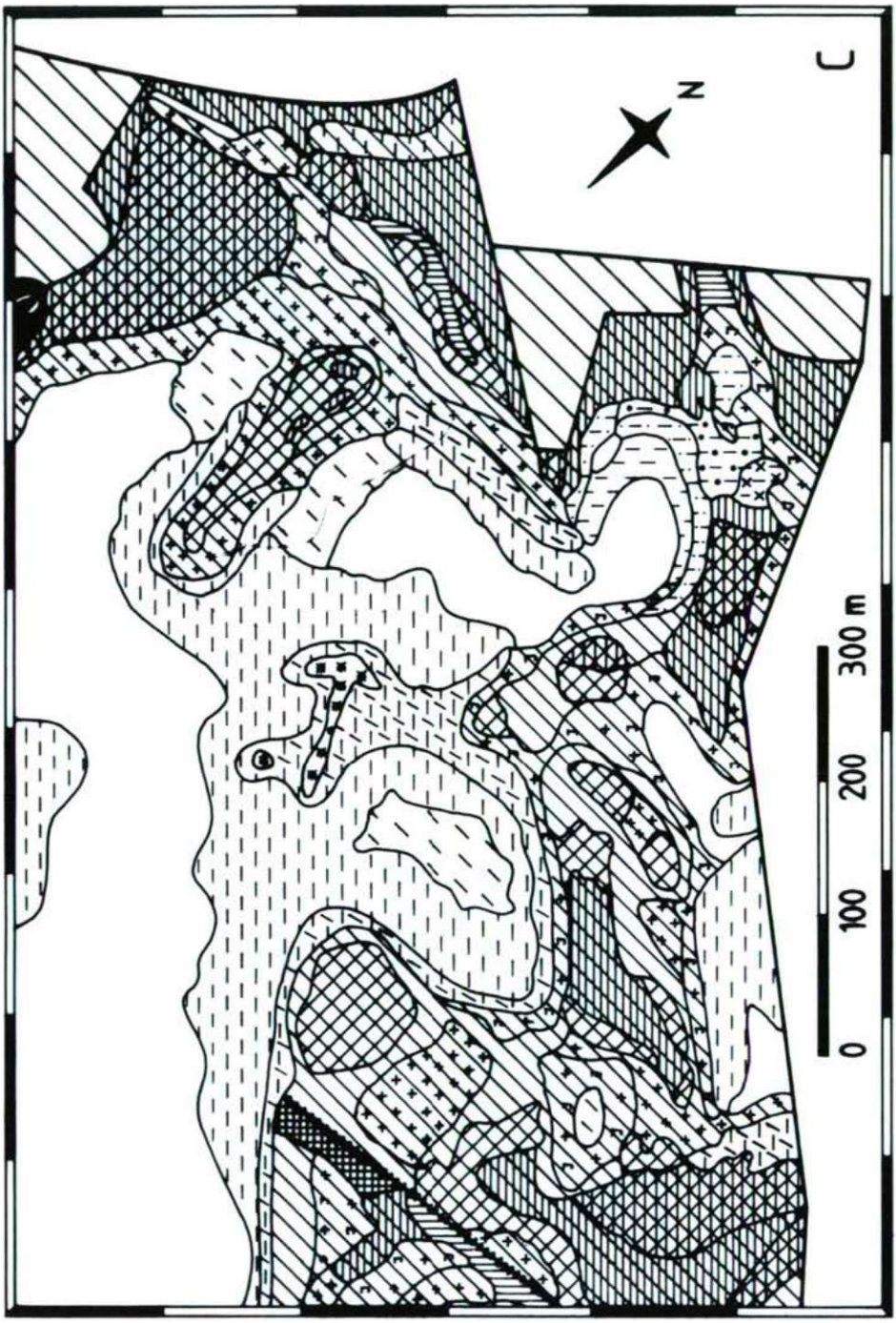
Key for the indentification of the units of the vegetation map:

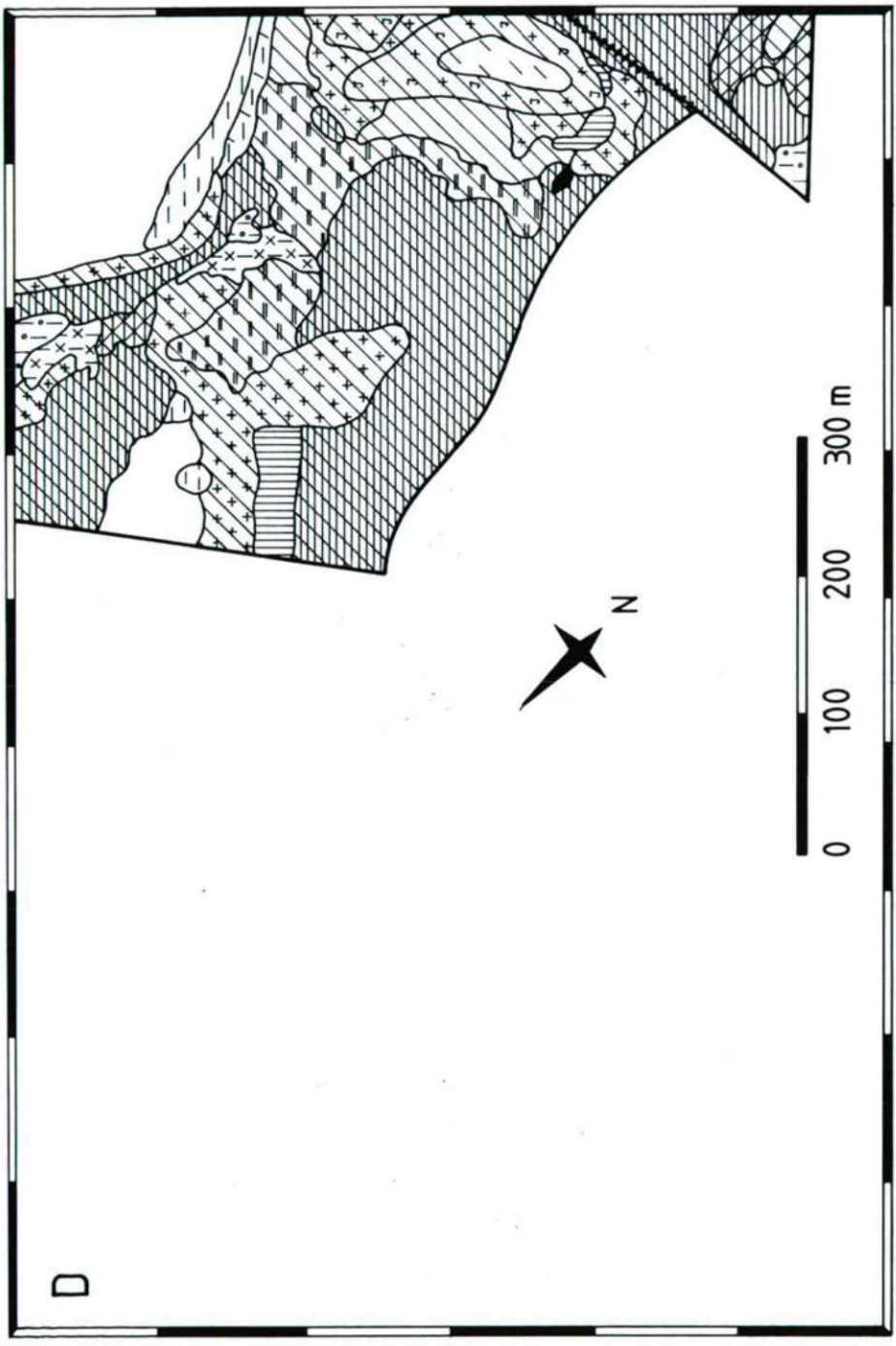
1. *Bolboschoenetum maritimi continentale*, 2. *Scirpo-Phragmitetum*, 3. *Scirpo-Phragmitetum asteretosum*, 4. *Scirpo-Phragmitetum agrostietosum stoloniferae*, 5. *Puccinellietum limosae*, 6. *puccinellietum limosae asteretosum*, 7. *Lepidio-Puccinellietum camphorosmetosum*, 8. *Lepidio-Puccinellietum typicum*, 9. *Bolboschoenus-Agrostis* complex, 10. *Agrostio-Caricetum distantis typicum*, 11. *Agrostio-Caricetum distantis asteretosum*, 12. *Agrostio-Caricetum Phragmites* facies, 13. *Agrostio-Caricetum Lotus tenuis* facies, 14. *Agrostio-Caricetum Lotus tenuis — Juncus compressus* facies, 15. *Agrostio-Caricetum Cynodon dactylon* facies, 16. *Agrostio-Caricetum distantis festucetosum pseudovinae*, 17. *Agrostio-Caricetum festucetosum pseudovinae Cynodon* facies, 18. *Agrostio-Caricetum festucetosum pseudovinae Limonium gmelinii* variante, 19. *Agrostio-Caricetum festucetosum arundinaceae*, 20. *Brometum tectorum*, 21. *Sisymbrion officinalis*, 22. *Agrostio-Caricetum festucetosum pseudovinae* x *festucetosum arundinaceae*, 23. *Agrostio-Caricetum Cynodon* facies x *festucetosum arundinaceae*, 24. *Agrostio-Carticetum Lotus* facies x *Phragmites* facies, 26. *Agrostio-Caricetum Lotus* facies x *Cynodon* facies, 27. Forests, clumps of trees, 28. Cultivated lands: plough lands, orchards.




A
N
0
100
200
300 m


N
0
100
200
300 m
B


C
N
0
100
200
300 m


D
N
0 100 200 300 m

ACTA BIOL. SZEGED. 34. PP. 97—106 (1988)

ECOFAUNISTICAL INVESTIGATION OF SPHECOID FAUNA ON A SANDY GRASSLAND

I. KARSAI

Department of Zoology, Attila József University
H—6701 Szeged, P. O. B. 695. Hungary

(Received: October 5, 1987)

Abstract

90 digger wasp species are reported from Bugacpuszta (Kiskunság National Park). *Miscophus helveticus* KOHL and females of *Crossocerus acanthophorus* (KOHL) proved to be new to the fauna of Hungary.

Tachysphex psammobius (KOHL) and *Tachysphex pompiliformis* (PANZER) were dominant species in the area investigated. More than three-quarters of the species were rare (<1% of individuals caught). Species were grouped according to their zoogeographical distribution, ecofaunistical character and prey species. The results may indicate the true roles of these categories if grouping is performed by taking the ratios of the numbers of individuals into consideration.

Palaearctic and European species play an important role in the composition of digger wasp fauna. Evaluating ecofaunistical characters, eremophilous species were dominant.

More than half of the species prey upon *Diptera, Orthoptera, Araneidea* and *Sternorrhyncha*. The predation pressure employed by digger wasps is the largest for *Orthoptera, Araneidea* and *Cicadinea*. The composition of sphecid assemblage is probably regulated by the availability of suitable nest sites and parasitation, although prey availability can also be important.

Key words: Sphecoidea, check list, zoogeographical distribution, ecofaunistical caracter, predation

Introduction

The purpose of my study was to establish a detailed faunistical list of digger wasps of a semi-natural part of a sandy grassland. The grouping of the species according to the quantitative characters (zoogeographical distribution, ecofaunistical characters and prey groups) is a rather superficial, but generally applied method. However, it can provide a suitable basis for further community ecology studies. Since more up-to-date (e.g. dynamic) zoogeographical data are not known for sphecid wasps, traditional categories have been used.

Very few faunistical reports on digger wasps are known that are based on large number of individuals and deal with the relative frequencies of the species found (HAESELER, 1972). The present aim was to determine the ratio of the applied qualitative characters (weighted on the basis of the frequency of species), and to establish relative frequencies. Data gained in this way may point to the role of the given category in the given habitat.

Numerous papers are known on the nesting and preying behaviour of digger wasps. These usually report the prey spectrum of one particular species (CALLAN,

1976; MILLER and KURCZEWSKI, 1976); occasionally they indicate quantitative data on prey species (DANKS, 1971; KROMBEIN, 1970). A number of authors considered the prey composition by orders and analysed them at this level (EVANS, 1970; WESTRICH, 1979). Most of the sphecid species prey on one order and, in the case of the few exceptions, most of the prey species belong to one order (EVANS, 1970; MILLER and KURCZEWSKI, 1975). However, if considerable differences in size or life-strategy (e.g. *Cicadinea* and *Sternorrhyncha*) or that of developmental stage (e.g. *Lepidoptera* and *Hymenoptera*) can be found within orders, it may be necessary to do further subdivisions.

Materials and methods

The investigated area is situated in the eastern part of the Bócsa-Bugac region of the Kiskunság National Park in Hungary. It consists of sand dunes with a maximum height of 1—3 metres. Because of the long-term intensive pasturage, the main plant association on the grazing land is *Potentillo-Festucetum pseudovinae* with scattered patches of ruderal associations (e.g. *Brometum tectorum*) (names after SOÓ (1964)). In 1976 a 2.4 ha plot of the pasture was fenced in to eliminate the destructive effect of the grazing. In the course of the secondary successional process, a *Festucetum vaginatae danubiale* plant association developed on the top of the dunes, and a *Molinio-Salicetum rosmarinifoliae* can be found in the hollows. Extremely hot and dry weather is characteristic of this area in the annual activity period of digger wasps (KÖRMÖCZI et al., 1981).

Sixty pan traps were used to collect insects within the enclosed area from 1983 to 1985. Traps were plastic bowls (15 cm diameter, rim 6 cm) lowered 2 cm deep in the soil. They contained ethylene-glycol as killing agent and preservative. Traps were emptied fortnightly from May to November. In 1986, 48 pan traps (size:50x25x4 cm) were placed onto the enclosed area and its environs. These traps contained water and detergent (Tip 67). In the main activity period of the digger wasps, from June to August (JÓZAN, 1985), these traps were set up for three days every two weeks. Additional collecting was made by hand picking. Possible prey species were collected by 70 pitfall traps from April to November.

For identification, I used the keys by BALTHASAR (1972), PULAWSKI (1971), LOMHOLD (1975), BAJÁRI (1957), MÓCZÁR (1959) and BOHART and MENKE (1976). Publications by JÓZAN (1985) and BENEDEK (1970), were used for geographical distribution; JÓZAN (1985) and WESTRICH (1979) for ecofaunistical categorization; OLBERG (1959), BALTHASAR (1972) and BAJÁRI (1957) for prey species.

Results and Discussion

Total of 90 species were caught on the studied area between 1983 and 1986, many more than previously known from the Bócsa—Bugac region of the Kiskunság National Park (JÓZAN, 1986). Five species were caught by hand picking only (Table 1, species denoted by an exclamation mark); 85 species (2765 individuals) were found exclusively in pan traps (only these were included for quantitative analysis).

Miscophus helveticus KOHL proved to be new to the fauna of Hungary. Females of *Crossocerus acanthophorus* (KOHL) were caught in Hungary for the first time; JÓZAN (pers. comm.) collected males in Tihany. The most typical genera in this area were *Tachysphex, Oxybelus, Miscophus* and *Diodontus* respecting the number of species and individuals. It is worth noting the presence of the subendemic *Oxybelus dissectus elegans* MOCSÁRY.

Table 1. Number (N) and relative frequency (RF%) of sphecid species caught (+ = RF%<0.1; ! = caught by hands).

Species	N 1983—1985 pan trap A	RF%	N 1986 pan trap B	RF%	N total	RF%
Dolichurus						
— *corniculus* (SPINOLA) 1808	0	0	4	0.49	4	0.14
Podalonia						
— *luffi* (SAUNDERS) 1903	103	5.30	5	0.61	108	3.90
— *affinis* (KIRBY) 1798	8	0.41	0	0	8	0.29
Ammophila						
— *terminata mocsáryi* FRIDVALDSKY 1876	5	0.26	0	0	5	0.18
— *campestris* LATREILLE 1809	3	0.15	0	0	3	0.11
— *sabulosa* (LINNAEUS) 1758	9	0.46	0	0	9	0.32
Sceliphron						
— *destillatorium* (ILLIGER) 1807	0	0	2	+	2	+
Sphex						
— *rufocinctus* BRULLE 1833	34	1.75	4	0.49	38	1.37
Prionyx						
— *kirbyi* (VANDER LINDEN) 1827	5	0.26	1	0.12	6	0.22
Diodontus						
— *minutus* (FABRICIUS) 1793	37	1.90	128	15.57	165	5.97
— *insidiosus* SPOONER 1938	26	1.34	32	3.89	58	2.10
— *major* KOHL 1901	0	0	1	+	1	+
Psenulus						
— *pallipes* (PANZER) 1798	0	0	2	+	2	+
Passaloecus						
— *gracilis* (CURTIS) 1834 !						
Mimesa						
— *caucasica* MAIDL 1914	1	+	0	0	1	+
Pemphredon						
— *inornatus* SAY 1824 !						
— *rugifer* DAHLBOM 1844	0	0	1	+	1	+
— *lugubris* (FABRICIUS) 1793 !	0	0	1	+	1	+
Astata						
— *rufipes* MOCSARY 1883	1	+	1	+	2	+
— *kashmirensis* NURSE 1909	1	0.05	7	0.58	8	0.30
— *minor* KOHL 1885	2	+	0	0	2	+
— *boops* (SCHRANK) 1781	1	+	0	0	1	+
— *costae* A.COSTA 1867	0	0	1	+	1	+
Dryudella						
— *tricolor* (VANDER LINDEN) 1829	64	3.29	21	2.55	85	3.07
Dinetus						
— *pictus* (FABRICIUS) 1793	6	0.31	0	0	6	0.22
Tachytes						
— *europaeus* KOHL 1884	92	4.74	10	1.22	102	3.70
— *etruscus* (ROSSI) 1790	2	+	0	0	2	+
— *obsoletus* (ROSSI) 1792	3	0.15	3	0.37	6	0.22
Tachysphex						
— *fulvitarsis* (COSTA) 1867	31	1.60	10	1.22	41	1.48

— *grandii* BEAUMONT 1965	21	1.08	2	0.24	23	0.83
— *helveticus* KOHL 1885	33	1.70	19	2.31	52	1.88
— *nitidus* (SPINOLA) 1805	14	0.72	1	0.12	15	0.54
— *pompiliformis* (PANZER) 1804	293	15.08	73	8.88	366	13.24
— *psammobius* (KOHL) 1880	391	20.12	1	0.12	392	14.18
— *panzeri* (VANDER LINDEN) 1829	2	0.10	1	0.12	3	0.11
— *obscuripennis* (SCHENCK) 1857	123	6.33	26	3.16	149	5.39
Palarus						
— *variegatus* (FABRICIUS) 1781	3	0.15	0	0	3	0.11
Larra						
— *anathema* (ROSSI) 1790	1	+	0	0	1	+
Nitela						
— *fallax* KOHL 1884	0	0	1	+	1	+
Solierella						
— *compedita* (PICCOLI) 1869	8	0.41	3	0.37	11	0.40
Miscophus						
— *bicolor* JURINE 1807	18	0.93	7	0.85	25	0.90
— *concolor* DAHLBOM 1844	12	0.62	6	0.73	18	0.65
— *spurius* (DAHLBOM) 1832	106	5.46	37	4.50	143	5.17
— *helveticus* KOHL 1883	0	0	3	0.36	3	0.11
Trypoxylon						
— *scutatum* CHEVRIER 1867	8	8.41	164	19.95	172	6.22
— *attenuatum* F.SMITH 1851	1	0.05	3	0.37	4	0.14
— *clavicerum* LEP. & SERV. 1828 !						
— *fronticorne* GUSSAKASKÍJ 1936	1	0.05	2	0.24	3	0.11
Oxybelus						
— *latro* OLIVIER 1811	5	0.26	1	0.12	6	0.22
— *bipunctatus* OLIVIER 1811	3	0.15	2	0.24	5	0.18
— *dissectus elegans* MOCSÁRY 1879	2	+	0	0	2	+
— *quattuordecimnotatus* JURINE 1807	50	2.57	36	4.38	86	3.11
— *victor* LEPELETIER 1845	65	3.35	10	1.22	75	2.71
— *variegatus* WESMAEL 1852	6	0.31	0	0	6	0.22
— *latidens* GERSTAECKER 1867	1	+	0	+	1	+
— *aurantiacus* MOCSÁRY 1883	1	0.05	2	0.24	3	0.11
— *argentatus gerstaeckeri* P.VERH. 1948	1	+	0	+	1	+
Entomognatus						
— *brevis* (VANDER LINDEN) 1829	1	+	0	0	1	+
Crossocerus						
— *quadrimaculatus* (FABRICIUS) 1793 !						
— *acanthophorus* (KOHL) 1892	0	0	1	+	1	+
Lestica						
— *alata* (PANZER) 1797	5	0.26	0	0	5	0.18
Lindenius						
— *panzeri* (VANDER LINDEN) 1829	1	+	1	+	2	+
— *albilabris* (FABRICIUS) 1793	1	+	0	0	1	+
Crabro						
— *peltarius* (SCHREBER) 1784	2	+	0	0	2	+
Ectemnius						
— *confinis* (WALKER) 1871	1	+	0	0	1	+
— *cavifrons* (THOMSON) 1870	2	+	0	0	2	+
— *lituratus* (PANZER) 1804	1	+	0	0	1	+
— *continuus* (FABRICIUS) 1804	0	0	1	+	1	+

Mellinus						
— *arvensis* (LINNAEUS) 1758	10	0.52	0	0	10	0.36
Alysson						
— *spinosus* (PANZER) 1801	5	0.26	23	2.80	28	1.01
Brachystegus						
— *scalaris* (ILLIGER) 1807	1	+	0	0	1	+
Nysson						
— *dimidiatus* JURINE 1807	55	2.83	1	0.12	56	2.03
— *maculosus* (GMELIN) 1790	25	1.29	1	0.12	26	0.94
— *roubali* ZAVADIL 1937	7	0.36	0	0	7	0.25
— *tridens* GERSTAECKER 1867	3	0.15	0	0	3	0.11
— *niger* CHEVRIER 1868	1	+	0	0	1	+
Dineoplus						
— *laevis* (LATREILLE) 1792	3	0.15	1	0.12	4	0.14
— *elegans* (LEPELETIER) 1832	12	0.62	2	0.24	14	0.51
— *moravicus* (SNOFLAK) 1946	44	2.26	21	2.55	65	2.35
Gorytes						
— *albidulus* (LEPELETIER) 1832	1	+	0	0	1	+
— *sulcifrons* (A. COSTA) 1869	3	0.15	0	0	3	0.11
Bembecinus						
— *tridens* (FABRICIUS) 1781	128	6.59	130	15.8	258	9.33
Bembix						
— *megerlei* DAHLBOM 1845	3	0.15	0	0	3	0.11
— *rostrata* (LINNAEUS) 1758	1	+	0	0	1	+
Philanthus						
— *triangulum* (FABRICIUS) 1775	7	0.36	0	0	7	0.25
Cerceris						
— *arenaria* (LINNAEUS) 1758	4	0.21	1	0.12	5	0.18
— *albofasciata* (ROSSI) 1790	10	0.51	6	0.73	16	0.58
— *rybyensis* (LINNAEUS) 1771	1	+	0	0	1	+
— *sabulosa* (PANZER) 1799	1	+	0	0	1	+
— *flavilabris* (FABRICIUS) 1793	1	+	0	0	1	+

Tachysphex psammobius (KOHL) and *Tachysphex pompiliformis* (PANZER) were the dominant species (Table 1). Relative frequencies (RF%) of both species were above 10% (pooled data). *Tachysphex obscuripennis* (SCHENK), *Diodontus minutus* (FABRICIUS), *Trypoxylon scutatum* CHEVRIER, *Miscophus spurius* (DAHLBOM) and *Bembecinus tridens* (FABRICIUS) were also common species. More than the three-quarters of the species (66 from 85) were rare (RF<1 %); supposedly, they have little ecological importance.

Differences in the result were caused not only by the differences in methods but probably by the large fluctuation of sphecid populations, too. A possible cause of this phenomenon may be parasitization (EVANS, 1970).

One-quarter of the species (25.5%) was Palaearctic (Fig. 1/a). The frequencies of the European, Ponto- and Holomediterranean species were lower, but noteworthy.The weighting of zoogeographical categories on the basis of specimen number altered the ratios of Palaearctic and various Mediterranean categories to small extents, but the value for the European group increased by more than 150%

(Fig. 1/b). The values for the Holarctic and Central European groups decreased nearly to zero. This indicated that the importance of these categories with low numbers of species and individuals was negligible.

The significance of Mediterranean species is usually emphasized when evaluating the composition of sphecid fauna of the Kiskunság National Park, and particularly at Bugac (JÓZAN, 1986). Though their pooled frequency was considerable (36.5%, the weighted value is 35.7%), the Palaearctic and European species were more important when the number of individuals caught were considered.

The distribution of the species according to the ecofaunistical characters may reflects the quality and the environmental conditions of the habitat; this gives a method for habitat comparisons (WESTRICH, 1979; JÓZAN, 1986). Nearly the three-quarters (72,1%) of the total number of species were eremophilous, and the ratio of stenoecious-eremophilous species was high (Fig. 2/a). Only a few hylophilous, and no stenoecious hylophilous species were found. Weighting (based on the number of individuals caught) reduced the participation of hylophilous species almost to zero and increased the proportion of eurioecious eremophils (Fig. 2/b). It indicated that the area studied was suitable habitat for thermophilous species. Supposedly hylo-

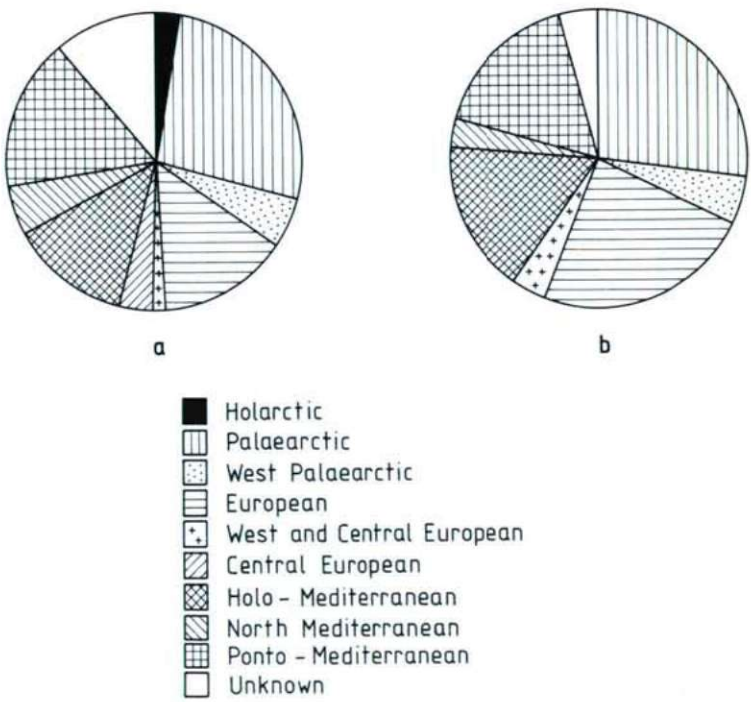


Fig. 1: Distribution of Sphecid assamblage according to zoogeographical distribution:
a: all species,
b: weighted on basis of relative frequency of sphecid species found in traps

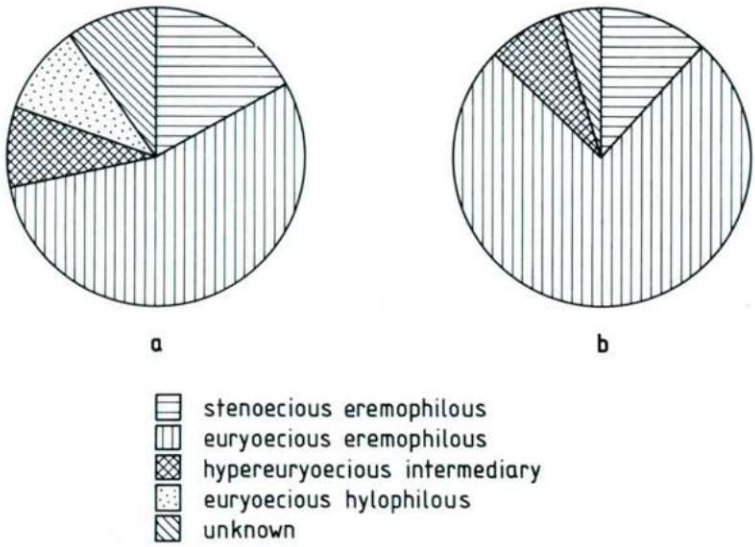


Fig. 1: Distribution of Sphecid assamblage according to ecofaunistical character:
a: all species,
b: weighted on basis of relative frequency of sphecid species found in traps

philous species may try to colonize, but the numbers and sizes of vegetation patches with a favourable microclimate (e.g. a *Molinio-Salicetum rosmarinifoliae* plant association) are too small. Accordingly, stable assemblages which are characteristic of this type of habitat, can not develop (KARSAI, 1988).

More than the half of the species prey upon four groups (*Diptera, Orthoptera, Araneidea* and *Sternorrhyncha*) and these seem to be the most important prey-groups. Participation of prey groups counted on the basis of the number of individuals of every single wasp species reflect the predation pressure of digger wasps on certain prey groups. In the course of this evaluating process, the predation pressure values for Hymenoptera larvae and adults, and for *Coleoptera* and *Lepidoptera* adults was negligible (Fig. 3/b). The predation pressure on *Orthoptera* was very high; that on *Cicadinea* and *Araneidea* was also considerable. The relevance of this effect is reasonable if we consider the high fecundity and high efficiency of preying (about 100 prey/wasp) (EVANS, 1970; DANKS, 1971). The values of predation pressure in case of *Diptera* and *Sternorrhyncha* decreased strongly. This relates to the fact, that in spite of great number of sphecid species preying upon these group, the pooled number of wasp individuals is low. (Fig. 3/a).

Sternorrhyncha comprises the majority of the all insects caught with pitfall traps (possible prey species) (Fig. 3/c). They probably represent large oversupply for wasps (EVANS, 1970) and as the wasps which prey on this group are not very common, they are not limited by the quantity of their prey. *Hymenoptera* also constituted a considerable part of prey species, but most of them were small-sized

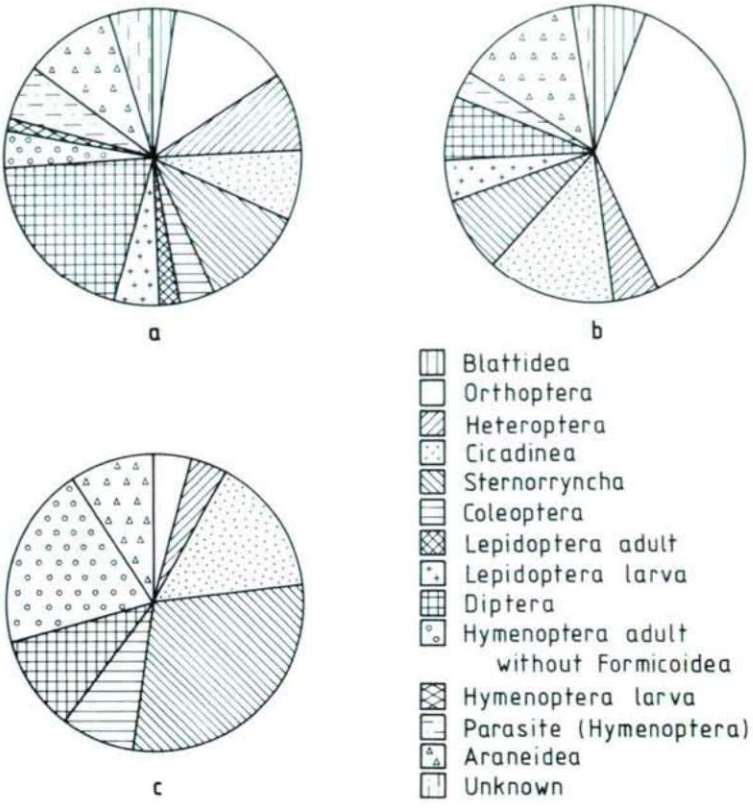


Fig. 1: Distribution of Sphecid assamblage according to prey species:
a: all species,
b: weighted on basis of relative frequency of sphecid species found in traps
c: distribution of possible prey species (caught in pitfall traps)

chalcid wasps, which were not preyed by digger wasps. The proportion of *Diptera* and *Cicadinea* from the potential prey species caught are nearly consistent with the level of predation pressure. In case of *Araneidae* this value is lower than that of predation pressure, but pitfall traps underestimate the abundance of web spider (MERETT and SNAZELL, 1983) and *Orthoptera* (SZŐNYI and KINCSEK, 1986). This, and the fact that Orthopteras are abundant only on the pasture was responsible for the same type of deviation is case of *Orthoptera*.

The composition of digger wasp assemblage is probably regulated by the availability of suitable nest sites (DANKS, 1971; KROMBEIN, 1967) and parasitization (EVANS et al., 1980; JACOB—REMACLE, 1986; PECKHAM, 1977; WCISLO et al., 1985), although prey availability can also be important.

Acknowledgements

I wish to thank ZS. JÓZAN for his help in species identification and L. GALLÉ and G. L. LÖVEI for useful comments.

References

BAJÁRI, E. (1957): Kaparódarázs alkatúak I. — *Sphecoidea* I. — Akadémiai kiadó, Budapest

BALTHASAR, V. (1972): Grabwespen — *Sphecoidea*. — Academia, Praha.

BENEDEK, P. (1970): A Bakony hegység kaparódarázs faunájának állatföldrajzi vizsgálata (Zoogeographical study of the Sphecid wasps of the Bakony mountain. In Hungarian with English summary). — Veszprém m. Múz. Közl. *14*, 221—238.

BOHART, R. M. and MENKE, A. (1976): Sphecid wasps of the world: a generic revision. — Univ. of Calif. Press, Berkeley.

CALLAN, E. McC. (1976): Observations on the nesting behavior and prey of *Gorytine* wasps in Trinidad. — Psyche *83*/3—4, 324—335.

DANKS, H. V. (1970): Biology of some stem-nesting aculeate *Hymenoptera*. — Trans. R. ent. Soc. Lond. *122*, 323—399.

DANKS, H. V. (1971): Nest motality factors in stem-nesting aculeate Hymenoptera. — J. Anim. Ecol. *40*, 72—82.

EVANS, H. E. (1970): Ecological-behavioral studies of the wasps of Jackson Hole, Wyoming. — Bull. Mus. Comp. Zool. *140*/7, 451—511.

EVANS, H. E., KURCZEWSKI, F. E. and ALCOCK, J. (1980): Observations on the nesting behaviour of seven species of *Crabro (Hymenoptera, Sphecidae)*. — Journal of Natural History *14*, 865—882.

HAESELER, V. (1972): Anthropogene Biotope (Kahlschlag, Kiesgrube, Stadtgarten) als Refugien für Insekten, untersucht am Beispiel der *Hymenoptera Aculeata*. — Zool. Jb. Syst. Bd. *99*, 133—212.

JACOB-REMACLE, A. (1986): Mortalité de quelques Hyménoptéres Aculéates nidifiant dans des nichoirs-piéges. — Bull. Annls Soc. r. belge Ent. *122*, 107—118.

JÓZAN, ZS. (1985): Dél-Dunántúl kaparódarázs *(Hymenoptera, Sphecoidea)* faunájának alapvetése (Fundamental faunistic data on Sphecoid wasps of South-Transdanubia, Hungary. In hungarian with English summary). — Janus Pannonius Múzeum Évkönyve, Pécs.

JÓZAN, ZS. (1986): The *Scolioidea* and *Specoidea* fauna of the Kiskunság National Park. In: The fauna of the Kiskunság National Park (ed.: MAHUNKA, S.). Akadémiai kiadó, Budapest, 365—381.

KARSAI, I. (1986): Sphecidae populációk faunisztikai és ökológiai vizsgálata homokpusztai gyepen (Faunistical and ecological studies of the *Sphecidae* populations on a sandy grassland. In Hungarian) —Diplomamunka.

KÖRMÖCZI, L., BODROGKÖZY, GY. and HORVÁTH, I. (1981): Investigation of biological production and bioclimate of sandy grasslands in Bugac (Great Hungarian Plain between Danube and Tice). — Acta Biol. Szeged. *27*, 55—69.

KROMBEIN, K. V. (1967): Trap-nesting wasps and bees: life histories, nests, and associates. — Smithsonian Press, Washington.

KROMBEIN, K. V. (1970): Behavioral and life-history notes on three floridian solitary wasps. — Smithsonian contributions to Zoology *46*, 1—26.

LOMHOLDT, O. (1975): The *Sphecidae* of Fennoscandia and Denmark. — Fauna entomologica Scandinavica 4/1—2 Scandinavian Science Press LTD., Klampenborg.

MERRETT, P. and SNAZELL, R. (1983): A comparison of pitfall trapping and vacuum sampling for accessing spider faunas on heathland at Ashdown Forest, south-east England. — Bull. Br. Arachnol. Soc. *6*/1, 1—13.

MILLER, R. C and KURCZEWSKI, F. E. (1975): Comparative behavior of wasps in the genus *Lindenius (Hymenoptera: Sphecidae, Crabroninae)*. — New York Entomological Society *83*, 82—120.

MILLER, R. C. and KURCZEWSKI, F. E. (1976): Comparative nesting behaviors of *Crabro rufibasis* and *Crabro arcadiensis (Hymenoptera: Sphecidae: Crabroninae.* — The Florida Entomologist. *59/3,* 267—286.

MÓCZÁR, L. (1948): Die Seehöhe und die ökologischen Gesichtspunkte in der Bezeichnung zoogeographischer Gebietseinheiten. — Fragm. Faun. Hung. *11,* 85—89.

MÓCZÁR, L. (1959): Kaparódarázs alkatúak II. — *Sphecoidea* II. — Akadémiai kiadó, Budapest.

OLBERG, G. (1949): Das Verhalten der Solitären Wespen Mitteleuropas. — Veb Deutcher Verlag der Wissenschaften, Berlin.

O'NEILL, K. M. and EVANS, H. E. (1982): Patterns of prey use in four sympatric species of *Philanthus (Hymenoptera: Sphecidae)* with a review of prey selection in the genus. — J. Nat. Hist. *16,* 791—801.

PECKHAM, D. J. (1977): Reduction of miltogrammine cleptoparasitism by male *Oxybelus subulatus (Hymenoptera: Sphecidae).* — Ann. Entomol. Soc. Am. *70/6,* 823—828.

PULAWSKI, W. (1971): Les *Tachysphex* de la région paléarctique occidentale et centrale. — Panstwowe Wydawnictwo Naukove, Wroclaw.

SOÓ, R. (1964): A magyar flóra és vegetáció rendszertani és növényföldrajzi kézikönyve I. (Handbook of taxonomical and phytogeographical of a Hungarian flora and vegetation —I.—In Hungarian). — Akadémiai kiadó, Budapest.

SZŐNYI, G. and KINCSEK, I. (1986): Indication of spatial heteromorphy and community structure of *Acridoidea*-communities in a sandy grassland. — Acta Biol. Szeged. *32,* 141—156.

WCISLO, W. T., LOW, B. S. and KARR, C. J. (1985): Parasite pressure and repeated burrow use by different individuals of *Crabro (Hymenoptera: Sphecidae; Diptera: Sarcophagidae).* — Sociobiology *11/2,* 115—125.

WESTRICH, P. G. (1979): Faunistik und Ökologie der *Hymenoptera Aculeata* des Tübinger Gebiets, vor allem des Spitzbergs, unter besonderer Berücksichtigung der in Holz und Pflanzenstengeln nistenden arten. — Dissertation zur Erlangung des Grades eines Doktors der Naturwissenschaften.

ACTA BIOL. SZEGED. 34. PP. 107—111 (1988)

CARABID FAUNA OF A SANDY GRASSLAND

J. PREISZNER AND I. KARSAI

Department of Zoology, Attila József University
H—6701 Szeged, P. O. B. 695. Hungary

(Received: Marc l, 1988)

Abstract

58 carabid species were collected in four years on a sandy grassland (Kiskunság National Park) isolated from grazing. The four dominant species (*Zabrus spinipes* (F.), *Harpalus servus* (DUFT.), *Harpalus picipennis* (DUFT.) and *Calathus erratus* SAHLB.) made up 86.3% of the total number of specimens.
Key words: Carabidae, sandy grassland, faunistics

Introduction

Carabidae are an important group of generalist soil predators. Numerous laboratory and field studies have been performed concerning their environmental demands and nutrition (THIELE, 1977). Several papers have been published on carabid assemblages, too, mainly in forests or agroecosystems or under an oceanic climate in higher geographical latitudes (e.g. FERGUSON and MCPHERSON, 1985; LOREAU, 1983; 1984; STRÜVE-KUSENBERG, 1980; KLEINERT, 1983; NIEMELA et al., 1986; BAARS, 1979). Only a small part of the extensive literature reports on studies of ground beetles living on sandy grasslands under a continental climate (THIELE, 1977). The present paper describes qualitative and quantitative data on the carabid fauna of a typical sandy grassland in Hungary.

Study area and sampling methods

Our study area is situated in the eastern part of the Bócsa—Bugac region of the Kiskunság National Park, Hungary. It consists of sand-dunes with a height of 1—3 metres. Because of the long-term intensive grazing, the main plant association on the grazing land is *Potentillo-Festucetum pseudovinae* (names after SOÓ (1964)), with scattered patches of ruderal associations (e.g. *Brometum tectorum*).

In 1976, a 2.4 ha plot of pasture was fenced in to eliminate the destructive effects of grazing. In this area, *Festucetum vaginatae* plant association has developed on the top of the dunes, and *Molinio-Salicetum rosmarinifoliae* in the hollows, this reflects the secondary succession.

Several appropriate methods are known for sampling carabid assemblages (SOUTHWOOD, 1966; HORVATOVICH, 1981). We collected beetles not only with pitfall traps, but also by hand-picking. Pitfall trapping may underestimate carabid population densities compared with extraction methods (THIELE, 1977). The size-dependennt mobilities of the species and the differences in relative plant cover around the traps may distort frequency relations among species (REFSETH, 1980). In spite of these facts, a reliable relative size of a carabid population can be obtained trought continuous pitfall catches (BAARS, 1979).

On the presumably different sites, 14 groups of 5 pitfall traps containing ethylene-glycol as preservative were placed on the enclosed area. They were emptied fortnightly or monthly from April to November. The present analysis is based on 2686 specimens collected predominantly with the traps, but partly by hand, during four years (1979—1982).

Result and discussion

58 species were found on the study area during the four years. This is 19.7% of the total number of all the carabid species found so far in the whole (and highly heteromorph) Kiskunság National Park (ÁDÁM and MERKL, 1986). 77.2% of the present species were collected in the pitfall traps (Table 1). *Harpalus subcilindricus* DEJ. have not been collected from the areas of the National Park before.

The qualitative composition of the assemblage is similar to those described from other sandy areas (HEERD and MÖRZER-BRUYNS, 1960; THIELE, 1977). We found numerous psammophilic species (e.g. *Calathus erratus, Calathus melanocephalus* and *Harpalus servus*), that are often found in agricultural areas. Their occurrence is independent of the composition of the plant communities (SCHJOTZ-CHRISTENSEN, 1957; MOSSAKOWSKI, 1970; PREISZNER, 1987). The majority of the *Harpalus* species, which make up the 35% of the total number of species caught, are also psammophilic (THIELE, 1977). The high species richness of the *Harpalini* may be explained as "taxonomically closely related (carabid) species are also ecologically closely related, and will thus more often than not be found coexisting in the same habitats" (DEN BOER, 1980).

High heat conductivity and poor water retention ability of sandy soils are features preferred thermophilic (e.g. *Harpalus smaragdinus*) and xerophilic (e.g. *Amara fulva*) species (THIELE, 1977). Results of detailed studies on carabid beetles also emphasise the important effect of abiotic factors on the frequency and distribution of the species (THIELE, 1977; DEN BOER, 1980).

In spite of the great number of species, the cumulative relative frequency of the four dominant species (*Harpalus servus, Harpalus picipennis, Calathus erratus* and *Zabrus spinipes*) is 86.3%. Among them, *Zabrus spinipes* has extremely high relative frequency (34.1%). This species was described as a characteristic of a Southern—Russian sandy grassland (GHILAROV, 1961).

86% of the species were rare (RF%<1). Some of them may have immigrated from the forest (e.g. *Carabus violaceus*), the sodic soil areas (e.g. *Lophyridia lunulata*) or from bare, plantless areas (e.g. *Cicindela hybrida*).

Acknowledgments

The authors wish to thank GY. SZÉL and L. ÁDÁM for their help in identifying the species, L. GALLÉ and G. L. LÖVEI for useful comments.

Table 1. Total number of individuals (N) and relative frequency (RF%) of carabid beetles caught by pitfall trapping over four years (x denotes beetles caught by hand only).

Species	N	RF%
Cicindela hybrida LINNAEUS, 1758	1	0.04
Cicindela campestris LINNAEUS, 1758	x	
Cylindera germanica LINNAEUS, 1758	1	0.04
Cylindera arenaria FUESSLIN, 1775	x	
Lophyridia lunulata nemoralis OLIVIER, 1790	x	
Calosoma auropunctatum (HERBST, 1784)	1	0.04
Carabus violaceus LINNAEUS, 1758	x	
Carabus granulatus LINNAEUS, 1758	x	
Carabus cancellatus ILLIGER, 1798	x	
Scarites terricola BONELLI, 1813	3	0.11
Dyschirius aeneus (DEJEAN, 1825)	x	
Broscus cephalotes (LINNAEUS, 1758)	2	0.08
Trechus quadristriatus (SCHRANK, 1781)	2	0.08
Bembidion properans STEPHENS, 1829	1	0.04
Anisodactylus signatus (PANZER, 1797)	x	
Harpalus azureus (FABRICIUS, 1775)	x	
Harpalus rufipes (DE GEER, 1774)	6	0.22
Harpalus griseus (PANZER, 1797)	7	0.26
Harpalus flavescens (PILLER & MITTELPACHER, 1783)	2	0.08
Harpalus froelichi STURM, 1818	1	0.04
Harpalus hirtipes (PANZER, 1797)	1	0.04
Harpalus affinis (SCHRANK, 1781)	1	0.04
Harpalus melancholicus DEJEAN, 1829	1	0.04
Harpalus rubripes (DUFTSCHMID, 1812)	1	0.04
Harpalus smaragdinus (DUFTSCHMID, 1812)	21	0.78
Harpalus distinguendus (DUFTSCHMID, 1812)	1	0.04
Harpalus pygmaeus DEJEAN, 1829	x	
Harpalus autumnalis (DUFTSCHMID, 1812)	27	1.01
Harpalus serripes (QUENSEL, 1806)	x	
Harpalus servus (DUFTSCHMID, 1812)	544	20.25
Harpalus albanicus REITTER, 1900	3	0.11
Harpalus anxius (DUFTSCHMID, 1812)	3	0.11
Harpalus subcylindricus DEJEAN, 1829	1	0.04
Harpalus picipennis (DUFTSCHMID, 1812)	447	16.67
Harpalus tardus (PANZER, 1797)	2	0.08
Bradycellus harpalinus (SERVILLE, 1821)	x	
Acupalpus luteatus (DUFTSCHMID, 1812)	2	0.08
Pterostichus vulgaris (LINNAEUS, 1758)	x	
Calathus fuscipes (GOEZE, 1777)	36	1.34
Calathus erratus (C. R. SAHLBERG, 1827)	409	15.23
Calathus ambiguus (PAYKULL, 1790)	83	3.10
Calathus melanocephalus (LINNAEUS, 1758)	23	0.86
Dolichus halensis (SCHALLER, 1783)	x	
Zabrus spinipes (FABRICIUS, 1798)	917	34.14
Zabrus tenebrioides (GOEZE, 1777)	5	0.19
Amara equestris (DUFTSCHMID, 1812)	6	0.22
Amara aulica (PANZER, 1794)	2	0.08

Amara fulva (D. F. MÜLLER, 1776)	12	0.45
Amara anthobia VILLA, 1833	1	0.04
Amara ovata (FABRICIUS, 1792)	1	0.04
Amara lucida (DUFTSCHMID, 1812)	1	0.04
Amara aenea (DE GEER, 1774)	20	0.74
Amara bifrons (GYLLENHAL, 1810)	6	0.22
Amara municipalis (DUFTSCHMID, 1812)	1	0.04
Panagaeus bipustulatus (FABRICIUS, 1775)	2	0.08
Masoreus wetterhalli (GYLLENHAL, 1813)	75	2.79
Syntomus pallipes DEJEAN, 1825	1	0.04
Microlestes maurus (STURM, 1827)	3	0.11
Total	2686	100

References

ÁDÁM, L. and MERKL, O. (1986): *Adephaga* of the Kiskunság National Park I: *Carabidae (Coleoptera)*. In: The fauna of the Kiskunság National Park (Ed.: S. MAHUNKA). — Akadémiai Kiadó.

BAARS, M. A. (1979): Catches in pitfall traps in relation to mean densities of Carabid beetles. — Oecologia *41*, 25—46.

DEN BOER, P. J. (1980): Exclusion or coexistence and the taxonomic or ecological relationship between species.Netherlands Journal of Zoology *30*, 278—306.

FERGUSON, H. J. and MCPHERSON, R. M. (1985): Abundance and diversity of adult *Carabidae* in four soybean cropping system in Virginia. — J. Entomol. Sci. *20*, 163—171.

FREUDE, H., HARDE, K. W. and LOHSE, G. A. (eds.) (1976): Die Käfer Mitteleuropas. Familienreihe *Adephaga*. I. Familie: *Carabidae*. — Goecke et Evers, Krefeld.

GHILAROV, M. S. (1961): Die veranderung der Steppenbodenfauna unter dem Einfluss der künstlichen Bewaldung. — Beitr. Entom. *11*, 256—269.

HEERDT, P. F. VAN and MÖRZER—BRUYNS, M. F. (1960): A biocoenological investigation in the yellow dune region of Terschelling. — Tijdschr. Entomol. *103*, 225—275.

HORVATOVICH, S. (1981): A Barcsi borókás tájvédelmi körzet cicindelái, carabidái és dytiscidái (*Coleoptera*) (The cicindelid, carabid and dytiscid fauna of the *Juniper* Woodland of Barcs, Hungary — In Hungarian.) — Dunántúli Dolgozatok term. Tud. sor. *2*, 65—79.

KLEINERT, J. (1983): Ground beetles (*Coleoptera: Carabidae*) in selected habitats of lowland in southeastern Slovakia. — Biologia *38*, 981—989.

LOREAU, M. (1983): Le regime alimentaire de huit carabides (*Coleoptera*) communs in milieu forestier. —Acta OEcol. *4*, 331—343.

LOREAU, M. (1984): Population density and biomass of *Carabidae (Coleoptera)* in a forest community. — Pedobiologia *27*, 269—278.

MOSSAKOWSKI, D. (1970): Ökologische Untersuchungen an epigaischen atlantischer Moor— und Heidestandorts. — Z. Wiss. Zool. *181*, 233—316.

NIEMELA, J., HAILA, Y. and RANTA, E. (1986): Spatial heterogeneity of carabid beetle dispersion in uniform forests on the Aland Island, SW finland. — Ann. Zool. Fennici. *23*, 289—296.

PREISZNER, J. (1987): Effect of habitat heterogeneity on Carabid populations on a sandy grassland. — Acta Phytopatologica *22*, 433—438.

REFSETH, D. (1980): Ecological analyses of Carabid communities — potential use in biological classification for nature conservation. — Biol. Conserv. *17*, 131—141.

SCHJOTZ—CHRISTENSEN, B. (1984): The beetle fauna of *Corynephoretum* in the ground of the Mols Laboratory. — Nat. Jutl. *6—7*, 1—20.

SOÓ, R. (1964): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve I—VI. (Synopsis systematico-geobotanica florae vegetationisque I—VI. In Hungarian.) Budapest, Hungaria.

SOUTHWOOD, T. R. E. (1966): Ecological methods with particular reference to the study of insect population. — Methuen et Co., London.

STRÜVE-KUSENBERG, R. (1980): Untersuchungen über die Laufkäfer (*Coleoptera: Carabidae*) verschieden alter Brachlandflachen. — Drosera, *80*, 25—40.

SZÉKESSY. V (1958): Homokfutrinkák — *Cicindellidae*. — Fauna Hung. 34.

THIELE, H. U. (1977): Carabid beetles in their environment. — Springer Verlag, Berlin.

ACTA BIOL. SZEGED. 34. PP. 113—117 (1988)

FAUNISTIC STUDIES ON EPIGEIC SPIDER COMMUNITY ON SANDY GRASSLAND

J. KEREKES

Department of Zoology, Attila József University
H—6701, Szeged, P.O.B. 659. Hungary

(Received: May 10, 1988)

Abstract

As a result of the experiment on the sandy grassland of Kiskunság National Park between 1979—85 139 species of 20 *Araneidea* families have been defined. *Tarentula fabrilis* (CLERC, 1758) (*Lycosidae*) out of them is new to Hungary.

This paper contains the species list.

Key words: Araneidae, check list, sandy grassland

Complex ecological experiments have been carried on the Bugac area of the Kiskunság National Park since 1976 (MÓCZÁR et al., 1980). I find useful to show the data of the seven year sampling as they complete the spider-faunistic data on Kiskunság National Park (LOKSA, 1987)

The biotic and abiotic factors of the sampling have been shown by some papers (GALLÉ et al., 1985; KÖRMÖCZI et al., 1981.)

Sampling was taken by 70 Barber traps placed on the different parts of the grassland and worked from March to November every year (1979—85) and they were emptied every second week.

The following species list contains the values of the species individual number (n) as well as the dominance per cent (D%):

	n	D%
Eresidae		
1. *Eresus niger* (PATAGNE)	40	0,25
Titanoecidae		
2. *Titanoeca quadriguttata* (HAHN)	342	2,20
Dictinydae		
3. *Argenna subnigra* (O.P.-CAMBRIDGE)	24	0,15
4. *Argenna crassipalpis* DAHL	4	0.03
5. *Dictyna pusilla* THORELL	1	0,01
6. *Dictyna szaboi* CHYZER	10	0,06
7. *Lathys humilis* (BLACKWALL)	1	0,01
8. *Lathys puta* (O.P.-CAMBRIDGE)	3	0,02
Dysderidae		
9. *Harpactea rubicunda* (C.L. KOCH)	1	0,01

Agelenidae		
10. *Agelena gracilens* C.L. KOCH	1	0,01
11. *Agelena labyrintha* (CLERCK)	4	0,03
Hahniidae		
12. *Hahnia nava* (BLACKWALL)	5	0,03
Lycosiade		
13. *Arctosa figurata* (SIMON)	17	0,11
14. *Arctosa perita* (LATREILLE)	6	0,04
15. *Lycosa radiata* LATREILLE	87	0,56
16. *Lycosa sigoriensis* (LAXMANN)	1	0,01
17. *Pardosa agrestis* (WESTRING)	3	0,02
18. *Pardosa lugubris* (WALCKENAER)	7	0,04
19. *Pardosa palustris* LINNEAUS	49	0,31
20. *Pardosa prativaga* (L. KOCH)	2	0,01
21. *Pardosa pullata* (CLERCK)	9	0,06
22. *Pardosa proxima* (C.L. KOCH)	1	0,01
23. *Pardosa cribrata* (SIMON)	1	0,01
24. *Tarentula cuneata* (CLERCK)	2412	15,47
25. *Tarentula cursor* (HAHN)	940	6,03
26. *Tarentula fabrilis* (CLERCK)	99	0,63
27. *Tarentula mariae* F. DAHL	28	0,18
28. *Tarentula pulverulenta* (CLERCK)	231	1,48
29. *Tarentula schmidti* (HAHN)	155	1,00
30. *Tarentula sulzeri* PAVESI	89	0,57
31. *Tricca lutetiana* (SIMON)	29	0,19
32. *Trochosa robusta* (SIMON)	3	0,02
33. *Trochosa ruricola* (DE GEER)	17	0,11
34. *Trochosa spinipalpis* (F.O.P.-CAMBRIDGE)	6	0,04
35. *Trochosa terricola* THORELL	438	2,81
36. *Xerolycosa miniata* (C.L. KOCH)	126	0,81
Pisauridae		
37. *Pisaura mirabilis* (CLERCK)	6	0,04
Zoridae		
38. *Zora spinimana* (SUNDEVALL)	1	0,01
Oxypidae		
39. *Oxyopes heterophtalmus* LATREILLE	26	0,17
Araneidae		
40. *Argiope lobata* PALLAS	1	0,01
41. *Araneus adiantum* WALCKENAER	1	0,01
42. *Singa albovittata* WESTRING	5	0,03
Tetragnathidae		
43. *Pachygnatha clercki* SUNDEVALL	1	0,01
44. *Pachygnatha degeeri* SUNDEVALL	56	0,36
45. *Pachygnatha listeri* SUNDEVALL	4	0,03

	Lyniphiidae		
46.	*Bathyphantes gracilis* (BLACKWALL)	1	0,01
47.	*Centromerus expertus* (O.P.-CAMBRIDGE)	1	0,01
48.	*Centromerus sylvaticus* (BLACKWALL)	23	0,15
49.	*Diplostyla concolor* (WIDER)	1	0,01
50.	*Lepthyphantes angulipalpis* (WESTRING)	1	0,01
51.	*Lepthyphantes flavipes* (BLACKWALL)	5	0,03
52.	*Lepthyphantes tenuis* (BLACKWALL)	11	0,07
53.	*Lepthyphantes weihlei* (VON BROEN)	1	0,01
54.	*Linyphia hortensis* (SUNDEVALL)	1	0,01
55.	*Meioneta rurestris* (C.L. KOCH)	310	1,99
56.	*Microlinyphia pusilla* (SUNDEVALL)	1	0,01
57.	*Microneta viaria* (BLACKWALL)	8	0,05
58.	*Microneta spinigera* (BALOGH)	450	2,89
59.	*Porrhamma microphtalmum* (O.P.-CAMBRIDGE)	1	0,01
60.	*Stemonyphantes lineatus* (LINNAEUS)	21	0,13
	Erigoniade		
61.	*Ceratinella brevis* (WIDER	125	0,80
62.	*Mecopisthes perpusillus* (MILLER)	126	0,81
63.	*Pelecopsis parallel* (WIDER)	17	0,11
64.	*Pelecopsis radicicola* (L. KOCH)	2	0,01
65.	*Araeoncus humilis* (BLACKWALL)	16	0,10
66.	*Trichopterna cito* (O.P.-CAMBRIDGE)	667	4,28
67.	*Gongylidiellum murcidum* (SIMON)	1	0,01
68.	*Silometopus reussi* (THORELL)	2	0,01
69.	*Tigellinus furcillatus* (MENGE)	4	0,03
70.	*Acartauchenius scurillis* (O.P.-CAMBRIDGE)	9	0,05
71.	*Trichoncus affinis* KULCZYNSKI	1	0,01
72.	*Trichoncus hackmani* MILLIDGE	202	1,30
73.	*Erigone dentipalpis* (WIDER)	1	0,01
74.	*Oedothorax apicatus* (BLACKWALL)	1	0,01
75.	*Tapinocyba insecta* (L. KOCH)	1	0,01
76.	*Styloctetor romanus* (CAMBRIDGE)	1	0,01
	Theridiidae		
77.	*Enoplognatha thoracica* (HAHN)	4	0,03
78.	*Enoplognatha mandibularis* (H. LUCAS)	8	0,05
79.	*Euryopis quinqueguttata* (THORELL)	116	0,74
80.	*Asagena phalerata* (PANZER)	31	0,20
81.	*Theridium petraeum* L. KOCH	254	1,62
	Gnaphosidae		
82.	*Berlandina cinerea* (MENGE)	613	3,93
83.	*Gnaphosa spinosa* (KULCZYNSKI)	135	0,86
84.	*Drassodes lapidosus* (WALCKENAER)	24	0,15
85.	*Drassodes pubescens* (THORELL)	338	2,16
86.	*Drassodes villosus* (THORELL)	6	0,04
87.	*Haplodrassus signifer* (C.L. KOCH)	91	0,58
88.	*Haplodrassus capnodes* (THORELL)	8	0,05
89.	*Haplodrassus umbratilis* (L KOCH)	2	0,01
90.	*Echemus rhenanus* BERTKAN	1	0,01
91.	*Phaeocedus braccatus* (L. KOCH)	19	0,12

92. *Zelotes latreille* (SIMON)	36	0,23
93. *Zelotes lutetianus* (L. KOCH)	3	0,02
94. *Zelotes praeficus* (L. KOCH)	58	0,37
95. *Zelotes pusillus* (C.L. KOCH)	55	0,35
96. *Zelotes longipes* (L. KOCH)	1502	9,63
97. *Zelotes pedestris* (C.L. KOCH)	22	0,14
98. *Zelotes apricorum* (L. KOCH)	4	0,03
99. *Zelotes electus* (C.L. KOCH)	657	4,21
100. *Zelotes declinans* (KULCZYNSKI)	105	0,67
101. *Zelotes gracilis* (CANESTRINI)	1	0,01
102. *Micaria rogenhoferi* (HERMANN)	140	0,89
103. *Gnaphosidae* sp.	23	0,15
Clubionidae		
104. *Phrurolithus* minimus C.L. KOCH	277	1,77
105. *Cheiracanthium punctorum* (VILLERS)	58	0,37
106. *Cheiracanthium pennyi* CAMBRIDGE	12	0,07
107. *Clubiona neglecta* O.P.-CAMBRIDGE	1	0,01
108. *Microclubiona diversa* (O.P.-CAMBRIDGE)	1	0,01
Liocranidae		
109. *Agroeca brunnea* (BLACKWELL)	24	0,15
110. *Agroeca pullata* THORELL	202	1,29
Thomisiade		
111. *Oxyptila atomaria* (PANZER)	32	0,20
112. *Oxyptila scabricula* (WESTRING)	318	2,03
113. *Thomisus onustus* WALCKENAER	1	0,01
114. *Xysticus acerbus* THORELL	13	0,08
115. *Xysticus cristatus* (CLERCK)	4	0,03
116. *Xysticus erraticus* (BLACKWALL)	3	0,02
117. *Xysticus kempeleni* THORELL	1	0,01
118. *Xysticus kochi* THORELL	630	4,04
119. *Xysticus ninni* THORELL	867	5,56
120. *Xysticus robostus* (HAHN)	2	0,01
121. *Xysticus sabulosus* (HAHN)	4	0,03
122. *Xysticus pini* HAHN	4	0,03
123. *Thanatus arenarius* L. KOCH in THORELL	1020	6,54
124. *Thanatus formicinus* (CLERCK)	1	0,01
125. *Thanatus pictus* L. KOCH	2	0,01
126. *Tibellus maritimus* (MENGE)	1	0,01
127. *Tibellus oblongus* (WALCKENAER)	13	0,08
Salticidae		
128. *Myrmarachne formicaria* (DE GEER)	2	0,01
129. *Aelurillus v-insignitus* (CLERCK)	222	1,42
130. *Euophrys aequipes* (O.P.-CAMBRIDGE)	59	0,38
131. *Euophrys frontalis* (WALCKENAER)	17	0,10
132. *Evarcha arcuata* (CLERCK)	7	0,04
133. *Heliophanus flavipes* (HAHN)	31	0,20
134. *Neon rayi* (SIMON)	5	0,03
135. *Pellenes nigrociliatus* (L. KOCH)	9	0,05
136. *Philaeus chrysops* (PODA)	3	0,02

137. *Phlegra fasciata* (HAHN)	59	0,38
138. *Sitticus penicillatus* (SIMON)	94	0,60
139. *Sitticus zimmermanni* (SIMON)	1	0,01
140. *Salticiade* sp.	32	0,20
	15593	100,00

References

GALLÉ, L., H. HORNUNG, E., SZŐNYI, G. D., GYÖRFFY, GY. and KINCSEK, I. (1985): Komplex ökológiai vizsgálatok homokpusztai gyepen a Kiskunsági Nemzeti Park területén — In Tóth,K. (ed.): Tudományus kutatások a Kiskunsági Nemzeti Parkban, Hungexpo. 174—196.

KÖRMÖCZI, L., BODROGKÖZY, GY. and HORVÁTH, I. (1981):Investigation of biological production and bioclimate of sandy grasslands in Bugac (Great Hungarian plain between Danube and Tisza) — Acta Biol. Szeged. *27*, 55—69.

LOKSA, I. (1987): The spider fauna of the Kiskunság National Park (Araneae) — In: MAHUNKA,S. (ed): The Fauna of the Kiskunság National Park II. — Akadémiai kiadó, Budapest. 335—342.

MÓCZÁR, L., GALLÉ, L., GYÖRFFY, GY. and H. HORNUNG, E. (1980):Complex ecological investigations in a sandy soil grassland: aims end general methodology — Acta Biol. Szeged. *26*, 161—164.

ACTA BIOL. SZEGED. 34. PP. 119—131 (1988)

SELEKTIONSPROZESSE IN REZENTEN MENSCHLICHEN BEVÖLKERUNGEN

H. D. SCHMIDT

Abteilung Anthropologie und Wissenschaftsforschung, Universität Ulm, Am Hochsträss 8, D-7900 Ulm

(Einreichung des Manuskripts am 31. Mai 1988)

Zusammenfassung

Da beim Menschen der experimentelle Zugang nicht möglich ist, ist auch der Nachweis selektiver Vorgänge extrem schwierig.

In dieser Arbeit wird versuch, einige rezente Ergebnisse zusammenzufassen, die aufgrund serologischer und biochemischer, aber auch demographischer und pathologischer Daten auf abgelaufene oder noch im Gang befindliche Selektionsprozesse hinweisen. Ausserden werden einige Wege und Methoden zum Nachweis von Selektionsprozessen beim Menschen präsentiert.

Schlüsswörter: Rezente Populationen, Selektionsprozesse, Blutmerkmale, historische Demographie.

Theoretische Ansätze

In der Evolutionstheorie ist die Selektion als der wichtigste Faktor, der zu Veränderungen von Genfrequenzen führen kann, angesehen. Ein zunächst nur seltenes mutiertes Gen, das in einer bestimmten Umwelt dem Träger einen Vorteil verschafft, kann auf dem Weg über geringere Sterblichkeit oder höhere Fruchtbarkeit im Laufe der Generationen häufiger werden. Diese reproduktive Performanz bestimmter Genotypen im Vergleich zur Norm wird als Fitness bezeichnet und stellt das zentrale Konzept in der Selektionstheorie dar.

Die Fitness kann sich also auf zwei verschiedenen Wegen äussern:

1. Die genetische Konstitution vermindert die Chance eines Genotypen, das Erwachsenenalter zu erreichen (Verminderung der Variabilität).

2. Die genetische Konstitution verringert die Chance eines Genotypen, Nachkommen zu zeugen (Verringerung der Fertilität).

Medizinisch gesehen und vom Standpunkt der Gesellschaft aus gibt es wesentliche Unterschiede zwischen diesen beiden Phänomenen. Von der Populationsgenetik her ist diese Unterteilung aber nicht von grosser Bedeutung, da für das Endergebnis — also Genfrequenzänderung — keine Unterschiede zwischen einem Allel, das einen Spontanabort verursacht, und einem anderen, das für Sterilität verantwortlich ist, bestehen.

Selbst eine geringe Selektion kann ein wirksamer Faktor sein, durch den sich Allelenverhältnisse quantitativ von einem Extrem zum anderen verschieben. Wenn beispielsweise ein neues, dominantes Allel A^2 als heterozygoter A^1A^2-Genotyp seinen Träger befähigt, je Generation 1/1000 mehr Nachkommen hervorzubringen

als die gleiche Zahl A^1A^1-Individuen, so lässt sich errechnen dass es weniger als 10000 Generationen erfordert, um aus einer Population mit nur einem Bruchteil eines Prozentes an A^2-Allelen solche mit 50 % A^2-Allelen zu machen (Abb. 1a).

Um die Häufigkeit von A^2 von 50 % auf 90 % ansteigen zu lassen, erfordert es weniger als weitere 10000 Generationen. Der Anstieg über 90 % zum völligen Ersatz von A^1 durch A^2 erfolgt jedoch sehr langsam. Der Grund hierfür liegt darin, dass bei höheren Häufigkeitswerten für A^2 die meisten Individuen A^2A^2 und A^1A^2 und nur sehr wenige A^1A^1 sein werden. Damit veringert sich die Selektionswirkung gegenüber A^1A^1, sodass man sie praktisch vernachlässigen kann, während die Fortpflanzung von A^1A^2-Individuen das Fortbestehen von A^1-Allelen in der Population zur Folge hat (FREYE, 1986).

Bei Rezessiven ist dagegen Selektion nur bei Homozygoten wirksam. Das heisst, ein seltenes rezessives und nur gelegentlich homozygot auftretendes Allel bleibt zunächst dem selektiven Einfluss entzogen. Erst wenn es so häufig geworden ist, dass eine grössere Zahl von Homozygoten auftritt, kann sich hier die selektion bemerkbar machen (Abb. 1b).

Nachweis von Selektionsprozessen in menschlichen Bevölkerungen

So klar und deutlich das theoretische Konzept auch klingen mag, so ist der Nachweis selektiver Vorgänge beim Menschen doch extrem diffizil. Die experimentelle Evolutionsgenetik konnte durch Variierung kontrollierbarer Faktoren diesen Prozess direkt beobachten. Beim Menschen aber entfällt weitgehend der experimentelle Zugang zum Studium der Selektion.

Nach MORTON (1968) gibt es mindestens sieben methodische Ansätze, Selektionsprozesse nachzuweisen:

1. Man sucht nach systematischen Umweltunterschieden zwischen Bevölkerungen mit hohen und niedrigen Frequenzen bestimmter Allele.
2. Weicht der Anteil der Homo- und Heterozygoten signifikant vom Hardy-Weinberg'schen Gleichgewicht ab, so kann das auf Selektion gegenüber bestimmten Genotypen hinweisen.
3. Man kann nach Beziehungen zwischen Genotypen und spezifischen Krankheiten suchen.
4. Die verschiedenen Genotypen werden auf Fruchtbarkeits- und Sterblichkeitsunterschiede geprüft.
5. Sind die Genfrequenzen in verschiedenen Altersklassen oder in verschiedenen Generationen einer Bevölkerung verschieden, so können Selektionsprozesse daran beteiligt sein.
6. Auch Geschlechtsunterschiede in der Häufigkeit von Genen oder Genkombinationen können Hinweise auf Selektionsprozesse geben.
7. Weichen in einer Nachkommengeneration die Phänotypen signifikant von den nach dem Mendel'schen Spaltungsgesetz erwarteten Häufigkeiten ab so dürfte Selektion im Spiel sein.

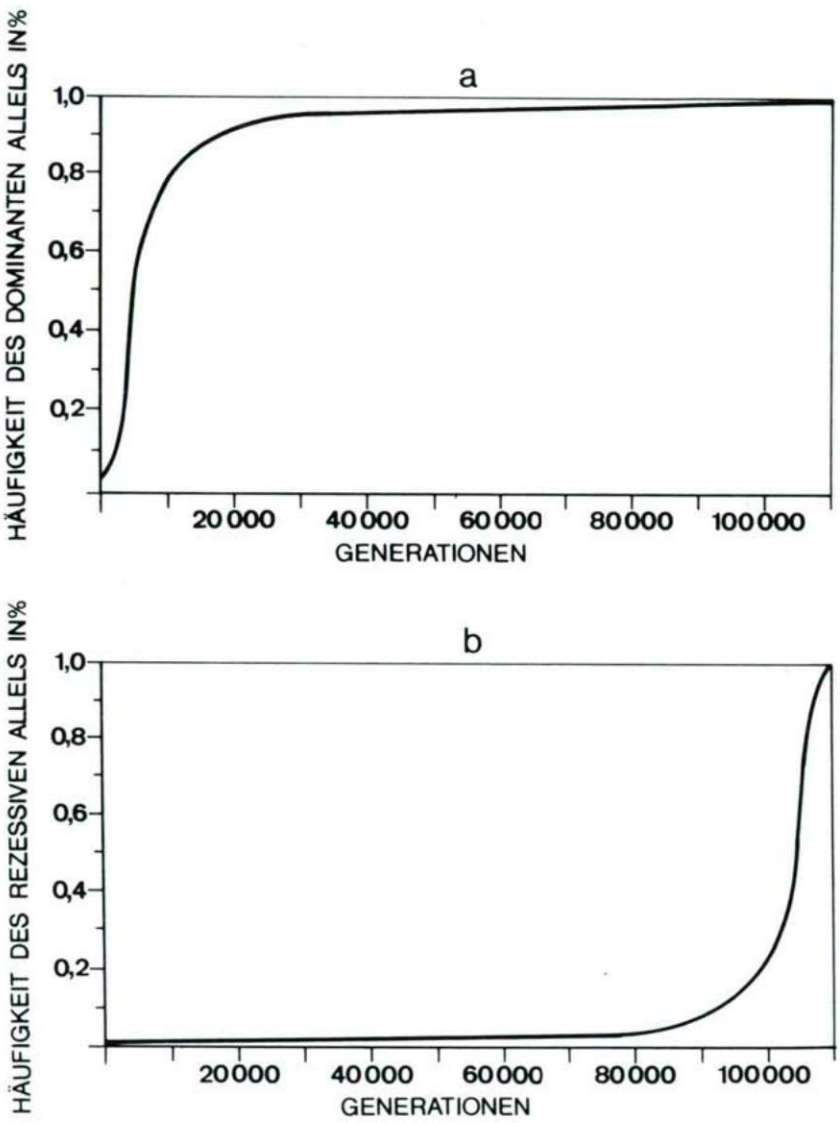


Abb. 1: Wirkung der Selektion a) zugunsten eines dominanten Allels b) zugunsten eines rezessiven Allels (nach STERN, 1968)

Infektionskrankheiten als Selektionsfaktoren

Als der bisher beste, wenn auch noch keineswegs vollkommen verständliche Selektionsmechanismus gilt der, der die Unterschiede in der Häufigkeit des Sichelzellgens in Verbindung mit der Malaria erklären konnte. Dem meisten Lesern ist dieser Mechanismus schon gut bekannt, darum verzichten wir, näher darauf einzugehen (siehe Literatur bei VOGEL und MOTULSKY, 1979). Es sollen in diesem Rahmen nur einige Folgen dieser extrem wichtigen Entdeckung erwähnt werden.

1. Es wurde zum ersten Mal gezeigt, dass Infektionskrankheiten eine selektive Kraft darstellen können.

2. Es wurde bewiesen, dass die Malaria ein extrem wichtiger Selektionsfaktor in der Evolution vieler Bevölkerungen aus dem tropischen und subtropischen Raum ist und dass möglicherweise auch andere Polymorphismen daran adaptiert sind.

3. Der Verdacht wurde geweckt, dass viele schädliche Gene, die in einigen Bevölkerungen in höheren Frequenzen auftreten, als man nur durch Mutationsdruckt erwarten kann, von einem balancierten Polymorphismus in Verbindung mit infektiösen Krankheiten erhalten bleiben.

4. Schliesslich wurde die Möglichkeit erwogen, dass viele der bekannten Polymorphismen wie z.B. die Blutgruppen, viele Serumproteine und Eythrozyten-Enzyme, balancierte Polymorphismen darstellen.

Diese Vermutungen wurden durch zahlreiche Untersuchungen geprüft, und die Ergebnisse haben viel Verständnis der genetischen Variation innerhalb menschlicher Bevölkerungen beigetragen.

Die Forschungsbemühungen der letzten Jahre führten zur Entdeckung auch anderer zahlreicher abnormer Hämoglobinvarianten, die in unterschiedlichen Häufigkeiten in den menschlichen Populationen auftreten. In Analogie zu dem Sichelzellgen wurde angenommen, dass die Varianten, die in höheren Frequenzen vorkommen, ebenfalls den heterozygoten Trägern eine bestimmte Resistenz gegen Malaria verschaffen. Obgleich wir heute über 300 verschiedene Hämoglobinvarianten kennen, sind es nur wenige, die polymorphische Frequenzen in grösseren Bevölkerungen erreichen: das HbS in grossen Teilen Afrikas, HbC in West-Afrika und HbE in Südost—Asien. Andere Varianten wurden, wenn auch nicht in hohen, so doch in polymorphischen Häufigkeiten innerhalb von kleinen, begrenzten Populationen gefunden; z.B: HbD_{Punjab} in Indien, HbG_{Accra} in Jamaica oder $HbO_{Indonesia}$ in Sulawesi (BENDER. 1983). Eine andere Krankheit, die wahrscheinlich mit Malaria in Verbindung steht, ist die Thalassämie — ein genereller Begriff für mehrer erbliche Krankheiten, die sich durch einen Defekt im Hämoglobinmolekül charakterisieren. Verschiedene genetische Mechanismen wie Punktmutationen, ungleiche Crossing-over oder Deletionen führen zu einer verminderten Produktion oder zum kompletten Fehlen des α oder β Globinmoleküls. Mit der modernen Technik kann man heute die spezifische Alteration in der DNA-Struktur und somit die verschiedenen Varianten der Thalassämie klar feststellen. In homozygoter Form führen einige Varianten zu schweren Anämien. Die geographische Verteilung mit hohen Frequenzen im Mittelmeerraum — z.B. werden von der schweren Form der

β-Thalassämie, im homozygoten Zustand als Cooley's Anämie bekannt, mehr als 1% aller Neugeborenen in einigen Gebieten Südeuropas betroffen — deutet auf eine Assoziation mit der Malaria hin. Einige experimentelle Untersuchungen, die von FRIEDMAN und TRAGER (1981) druchgeführt wurden, liefern hinweise, dass bei den heterozygoten Trägern eine zelluläre ungünstige Umwelt für die Entwicklung der Malaria-Erreger besteht.

Ähnliches wird auch für die Träger von G6PD-Mangel-Allele vermutet, die nach Einnahme von Drogen, Chemikalien, aber auch Naturstoffen wie Favabohnen, ein hämolytische Anämie aufzeigen. In diesen Fällen kommt es zu einer verminderten Konzentration von GSH, die zu einer Hemmung der Proteinsynthese bei Plasmodien führen kann. Ausserdem wurde statistisch nachgewiesen, dass die Häufigkeit der G6PD-Mangel-Allele parallel zur Häufigkeit von Malariafällen verläuft. Beeindrucken sind die Ergebnisse aus Sardinien; zahlreiche Fälle von G6PD-Mangel wurden in der Ebene gefunden, wo Malaria endemisch war, und nur wenige in der Gebirgszone, wo keine Malariafälle registriert wurden. Für andere genetische Marker waren die beiden Bevölkerungen indentisch (LIVINGSTONE, 1967).

Ein anderer direkter Beweis wurde von LUZZATTO und BIENZLE (1979) gebracht, die zeigen konnten, dass bei den heterozygoten Frauen (G6PD ist X-gebunden), die ja zwei verschiedene Zellpopulationen besitzen, der Grad der Parasitierung in den normale Erythrozyten höher war als in den Zellen mit G6PD-Mangel.

Es wurde immer wieder versucht, auch andere Polymorphismen wie z.B. Haptoglobine oder verschiedene Blutgruppen mit der Malaria in Verbindung zu bringen. Die meisten Studien führten aber nicht zu konkludenten Ergebnissen. Trotzdem konnten neuere Untersuchungen eine korrelation zwischen Malaria und den Duffy-Blutgruppen finden. MILLER und Mitarbaiter (1975 und 1976) zeigten, dass Duffy-negative Erythrozyten (Fy a-b-) gegenüber der Invasion von Plasmodium vivax resistent sind, oder umgehkert, dass Malariaplasmodien für das Eindringen in die Erythrozyten anscheinend die Antigene Fy^a und Fy^b als Rezeptoren benötigen. Das könnte ein wichtiger Selektionsfaktor sein, der auch die extrem hohen Häufigkeiten des Phänotypus Fy a-b- in vielen negriden Bevölkerungen Afrikas erklären kann. Dieser Phänotyp, fast unbekannt in anderen Bevölkerungen, findet sich bei den Negriden in einer Häufigkeit von 60 bis 90 %. Untersuchungen dieser Art haben mit Erfolg bewiesen, dass Malaria als selektiver Faktor viele genetische Polymorphismen bestimmt hat. Wie steht es aber mit anderen infektiösen Krankheiten? Bis heute konnten noch keine ähnlich guten und direkten Beweise, wie sie für die Malaria existieren, gefunden werden. Wir wissen aber, dass die Selektion besonders effektiv verläuft, wenn ihre Wirkung sich durch differentielle Mortalität bis ins Erwachsenenalter ausübt. Nun, unsere ersten Daten über Kindersterblichkeit in Europa stammen aus dem 18. Jahrhundert (RENNER und SCHMIDT, 1986). Mitte des 18. Jahhunderts starben in Zentraleuropa mehr als 50 % der Kinder, bevor sie das 20. Lebensjahr erreichten, und davon ca. die Hälfte noch im ersten Lebensjahr. Welches waren die Gründe dieses frühen Sterbens? Wir können diese Frage nur teilweise beantworten, da nicht alle Todesursachen jener Zeit identifiziert werden konnten. Jedenfalls gibt es keinen Zweifel, dass die meisten

Kinder an viralen und mikrobialen Krankheiten starben (Tab. 1). Deshalb muss man die Infektionskrankheiten als wichtige Auslöser von selektiven Mechanismen ansehen.

Tab. 1. Vergleich der Todesursachen in zwei Gebieten der Ulmer Umgebung in der zweiten Hälfte des 19. Jahrhunderts

Todesursache	Gebiet I	Gebiet II
Diphtherie	25,2	2,6
Typhus	30,7	1,2
Ruhr, Brechruhr (Magendarmkatarrh)	5,0	30,9

Nach VOGEL und MOTULSKY (1979) kommen vier Gruppen von Infektionskrankheiten in Betracht, die die Genfrequenz beeinflussen konnten:

1. Akute infektionen, die grosse Gebiete überfielen und einen grossen Teil der Bevölkerung betrafen, wie z.B. die Pest, die Cholera und die Pocken.
2. Chronische Infektionen wie Tuberkulose, Lepra und Syphilis.
3. Die Heterogene Gruppe der Darminfektionen, die bei Kleinkindern oft tödlich verliefen.
4. Tropische Krankheiten wie z.B. die Malaria.

Man hat versucht, anhand dieser Krankheitsgruppen die Existenz verschiedener Polymorphismen in den heutigen Bevölkerungen zu erklären. Ein Beispiel dafür die "AB0-Blutgruppen":

Die heutige Verteilung dieser Blutgruppen, die fast überall in der Welt polymorphisch erscheinen, weisen auf Selektionprozesse hin. Das Allel 0 ist häufig in Populationen, die für lange Zeit relativ isoliert waren wie z.B. die Aborigines in Australien und Polynesien, die Bevölkerung Nordsibiriens und der Arktis. Eine besonders hohe Häufigkeit von 0 finden wir bei den Indianern Zentral- und Südamerikas. Auch in Europa treffen wir hohe Anteile von 0 in isolierten oder Randpopulationen (Iren, Isländer, Basken, Korsen, Sarden, Valser). Die Gruppe B zeigt hohe Frequenzen vor allem in Indien und Zentralasien, von wo aus die Häufigkeiten nach Osten und Westen stufenweise abnehmen.

Es wurde der Versuch gemacht, diese unterschiedliche Verbreitung in Verbindung mit den grossen Pest- und Pockenepidemien, aber auch mit Syphilis und anderen infektiösen Krankheiten zu erklären. Diese Hypothesen stützen sich fast ausschliesslich auf historisches Material, direkte Beweise gibt es nur in Bezug auf rezente Pockenfälle in Indien (Abb. 2). Die Untersuchungen von VOGEL und HELMBOLD (1972) deuten darauf hin, dass die Träger der A- und AB-Blutgruppen viel häufiger an Pocken erkranken, schwere Symptome aufzeigen und öfter an Pocken sterben als die Träger von B- und 0-Gruppen. Dieser Selektionsnachteil des A-Allels könnte teilweise die höheren Frequenzen von B in den von Pocken betroffenen Gebieten Asiens erklären.

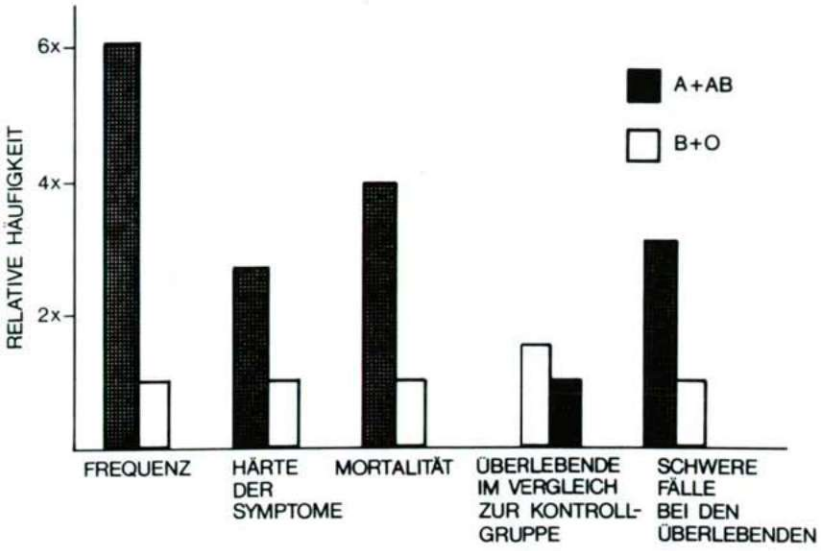


Abb. 2: Blutgruppenverteilung bei Pockenpatienten und Kontrollpersonen (nach VOGEL und MOTULSKY, 1979)

Obwohl direkte Beweise für einen selektiven Effekt dieser Krankheiten sehr spärlich sind, besteht kein Zweifel, dass infektiöse Krankheiten wie Pocken, Typhus oder Pest die ja viel mehr Todesopfer gefordert haben als genetisch bedingte Krankheiten, einen enormen selektiven Druck darstellten. Wenn es Gene gibt, die irgend einen Schutz gegen diese Krankheiten boten, so konnten diese Gene sich in der Bevölkerung schnell verbreiten.

Auf einen letzten Zusammenhang soll noch hingewiesen werden:

Vor einiger Zeit berechteten EALES und Mitarbeiter (1987), dass zwischen dem Gc-System und der AIDS-Erkrankung eine hohe Korrelation besteht.

Diese Studie basiert auf Untersuchungen an 203 Homosexuellen, die mit dem AIDS-Virus infiziert oder einem hohen Risiko ausgesetzt waren. Darunter befanden sich auch 16 Homosexuelle, die keine Infektion aufwiesen, obwhol sie regulären Kontakt mit bekannten AIDS-Trägern hatten. Als Kontrolle wurde eine Stichprobe von 50 zufällig gewählten Homosexuellen und 122 gesunden Heterosexuellen untersucht.

Das auffälligste Ergebnis war, dass unter denjenigen, die mit AIDS-Trägern Kontakt hatten, aber selbst nicht erkrankten, die meisten Gc 2—2 Homozygoten waren. Umgekehrt: diejenigen, die sich infizierten und schwere Symptome aufwiesen, waren vorwiegend Gc 1F—1F Homozygoten. Keiner der 63 AIDS-Erkrankten hatte das Gc^2 Allel doppelt vorhanden. Ausserdem war die Entwicklung von leichten zu schwere Formen der Krankheit streng mit dem Besitz eines Gc^{1F}, aber nicht mit einem Gc^2 Allel korreliert.

Die britischen Wissenschaftler verbinden diese Ergebnisse mit der biochemischen Struktur der drei Allele, die sich unter anderem durch unterschiedliche Mengen von Sialinsäuren unterscheiden. Gc^{1F} besitzt die Säure in doppelter Dosis, Gc^{1S} in einfacher Dosis, während Gc^{2} keine Sialinsäuren besitzt. Die Autoren sind der Meinung, dass die Sialinsäure auf irgeng eine Weise die Bindung des AIDS-Virus an den T4 Lymphozyten favorisiert und das Durchdringen des Virus durch die Zellmembranen ermöglicht.

In Bezug auf diese Ergebnisse ist interessant, zu erwähnen, dass in Zentral-Afrika, wo die AIDS-Krankheit viel häufiger auftritt als anderswo, das Gc^{1F} Allel auch häufiger vorkommt. So haben z.B. einige rezente Untersuchungen in Zentral-Afrika eine Häufigkeit von 58 % gefunden, während für Ulm und Umgebung unsere eigenen Untersuchungen einen Wert von 11 bis 14 % ergaben. Es stellt sich selbstverständlich die Frage, woher dieser gewaltige Unterschied in der Genfrequenz stammt. Die erwähnten Häufigkeiten charakterisieren grosse Bevölkerungen, und somit kommen nur Selektionsprozesse in Frage. Welches waren aber die auslösenden Faktoren? Nachdem bekannt wurde, dass das Gc-Protein die Transportfunktion für Vitamin D besitzt, hat man versucht, die Allelenhäufigkeit mit der Intensität der Sonnenbestrahlung in Verbindung zu bringen. Diese Untersuchungen führten aber zu keinen konkludenten Ergebnissen, und somit müssten es wahrschenlich andere Faktoren gewesen sein, die in vergangenen Generationen dem Gc^{1F} Allel in Afrika einen selektiven Vorteil oder umgekehrt in Europa einen selektiven Nachteil gebracht haben. Dieses Beispiel zeigt uns, wie sehr sich Selektionsprozesse in Raum und Zeit verändern können. Die Tatsache, dass die gleichen Genotypen in verschiedenen Gebieten, in verschiedenen Zeitperioden, ja sogar in verschiedenen Lebensetappen eines Individuums unterschiedliche Fitnesswerte bekommen können, führt zu grossen Schwierigkeiten in der Erforschung von Selektionsprozessen.

Korrelationen mit anderen Krankheiten

Nicht nur Infektionskrankheiten wurden mit verschiedenen Polymorphismen in Verbindung gebracht. Es stehen uns heute zahlreiche Arbeiten zur Verfügung, die anhand grosser Stichproben Korrelationen zwischen bestimmten Genotypen und Krankheiten beweisen konnten. Aus Tabelle 2 ist ersichlich, dass beispielsweise Patienten mit Karzinomen häufiger Angehörige der Blutgruppe A sind, Ulkusträger häufiger der Gruppe 0 oder Epileptiker öfter der Gruppe B zugehören.

Noch viel höhere Korrelationen bestehen zwischen einigen HLA-Allelen und bestimmten Krankheiten (Tabelle 3). So liegt z.B. für Individuen mit HLA-B 27 das relative Risiko mit 87 % höher, an Morbus Bechterew zu erkranken als für andere Personen.

Hohe Korrelationen bestehen auch zwischen B 27 und Morbus Reiter, Cw6 und Psoriasis, DR3 und Dermatitis herpetiformis und noch vielen anderen.

Tab. 2. Assoziationen zwischen Blutmerkmalen und Krankheiten (nach KNUSSMANN, 1980)

Krankheit	Blutmerkmal
Karzinome des Verdauungstraktes	A +
Eierstockkarzinom	A +
Gebärmutterkarzinom	A (+), D (+)
Brustkarzinom	A (+), M (—), Se (—)
Prostata-Karzinom	A (+)
Leukämie	Hpl +, D —
Magen-Darm-Geschwüre (Ulcera)	O +, Se —, D (+)
Leberzirrhose	A +, B (+)
chron. Leberentzündung (Hepatitis)	HLA—A1 (+), —B8 +
Gallenblasenentzündung, Gallensteine	A +
Zuckerkrankheit (Diabetes mellitus)	Se +, PTC —
Altersform	O (—)
juvenile Form	O (+), HLA—B7 —, —B8 +, —B15 +, —B18 (+)
Herzinfarkt	A +, B (+), D +
Arteriosklerose	A +, B (+)
Thrombose, Embolie	A +, B (+)
Heuschnupfen	D —
Asthma	A (+), B +, D (—)
Lungentuberkulose	A (—), D (—), Hp2 (+)
Lepra (nicht-tuberkulöse Formen)	A (+), D (+), Gc1 +, PTC +
Syphilis	O (—)
Scharlach	A (—)
Kinderlähmung (Poliomyelitis)	O (+)
Pocken	A +
Masern	A (—)
Mumps	O +
Grippe, Typ A	O +
Erkältungen (Adenoviren)	A +
Malaria	A +
Schuppenflechte (Psoriasis)	O (+), M +, HLA—B7 —, —B8 —, —B13 +, —B17 +, —B37 +
rheumatische Erkrankungen	O —, Se —, HLA—B27 +
(rheumatoide) Arthritis	O +, D +
Kurzsichtigkeit (Myopie)	O —
multiple Sklerose	O (+), HLA—A3 (+), —B7 (+)
Schizophrenie	B (+), M (—), HLA—A28 +
manisch—depressive Erkrankung	A (—), HLA—Bw16 +
Epilepsie	B +

Als Ursache dieser Assoziationen kommen nach PROKOP und GÖHLER (1986) mehrere Möglichkeiten in Frage:

1. Das HLA-Allel, das das korrespondierende Allel steuert, stellt ein Ir-Gen dar, das eine die Krankheit verursachende pathologische Immunantwort bewirkt.

2. Das HLA-Antigen stellt einen Rezeptor für ein Pathogen dar; oder es besitzt gemeinsame antigene Determinanten mit dem Pathogen und der Organismus bildet

keine Immunantwort; oder es wird durch den Pathogen verändert, wodurch es zu einer die Krankheit auslösenden Immunantwort kommt.

3. Einige Erkrankungen mit autosomal rezessivem Erbgang werden durch Genmutanten verursacht, die mit HLA-Allelen gekoppelt sein können, z.B. das adrenogenitale Syndrom durch 21-Hydroxylase-Mangel sowie die C2- und C4-Defizienzen.

Schwierigkeiten in der Erforschung von Selektionsprozessen

Wir haben bis jetzt nur über die Auswirkung von Selektionsfaktoren auf einzelne Genloci gesprochen. In den natürlichen Populationen ist die Lage viel komplizierter. Ein Mensch besitzt Tausende von Genloci. Die Selektion wirkt sich aber nicht auf die einzelnem Loci aus, sondern auf das gesamte Individuum, also auf die Kombination zwischen Genprodukt und Umwelt. Vom Standpunkt der Selektion aus ist der "bestgeeignete Gesamtphänotyp" entscheidend. Diese Gesamtheit

Tab. 3. Assoziationen zwischen HLA-Merkmalen und Krankheiten bei Europiden (nach SVEJGAARD, 1983)

Krankheit	Antigen des HLA-Systems	RR* %
Rheumatologie		
Morbus Bechterew	B27	87,4
Morbus Reiter	B27	37,0
Akute vordere Uveitis	B27	10,4
Juvenile Rheumatoid-Arthritis	D/DR5	5,2
Dermatologie		
Psoriasis vulgaris	Cw6	13,3
Dermatitis herpetiformis	D/DR3	15,4
Pemphigus	D/DR4	14,4
Neurologie		
Multiple Sklerose	D/DR2	4,1
Myasthonia gravis	D/DR3, B8	2,7
Endokrinologie		
Deabetes mellitus	D/DR2	0,2
	D/DR3	3,3
	D/DR4	6,4
Thyreotoxikose	D/DR3	3,7
Gastroenterologie		
Zöliakie	D/DR3, D/DR7	10,8
Idiopath. Hämochromatose	A3	8,2
	B14	4,7
Perniziöse Anämie	D/DR5	5,4

* RR = relatives Risiko, das angibt, wie viele Male die betreffende Krankheit bei den Merkmalsträgern häufiger ist als bei Antigennegativen Individuen

kann aber von zahlreichen und sehr komplexen Faktoren beeinflusst werden. Die menschliche Existenz ist sehr kompliziert, und in unserer langen Lebensspanne kann es viele Selektionsepisoden geben. Die Geschichte des Lebens wurde von GOULD (1977) als "lange Perioden von Langweile und kurze Perioden von Terror" bezeichnet. Vom Standpunkt der Selektion aus scheint das sehr zutreffend, denn es können im Laufe des Lebens für jeden Locus mehrere Selektionsepisoden gegeben sein, für die der Genotyp verschiedene Fitness-Werte besitzt.

Wir haben schon erwähnt, dass die Selektion als "differentieller reproduktiver Erfolg" definiert wird. Es ist klar, dass sich nicht jeder Mensch in gleichem Masse fortpflanzt, und diese Unterschiede sind teilweise auch genetisch bedinkt. DAMON (1977) schätzt, dass sich heute von der Gesamtzahl der Zygoten die meisten nicht weiter fortpflanzen (Abb. 3a). Ungefähr 50 % sterben vor der Geburt, 3 % sind Totgeburten, 2 % sterben kurze Zeit nach der Geburt und andere 3 % bis zum Erwachsenenalter. Von denjenigen, die das Erwachsenenalter erreichen, sind 20 %, die nie heiraten, und andere 10 % die heiraten, deren Ehe aber kinderlos bleibt. Übrig bleiben nur ca. 10 bis 15 %, die Nachkommen haben und somit ihre Gene weitervererben. Und diese Zahlen lagen in den vorigen Jahrhunderten noch viel höher.

Hier ein Beispiel aus unseren eigenen Untersuchungen in einem ländlichen Gebiet um Ulm (Tab. 4): Die Daten schildern die Zahl der im ersten Lebensjahr verstorbenen Kinder in vier Dekaden des 19. Jahrhunderts. Insgesamt wurden 4,9 % Totgeburten registriert; 3,4 % starben in der ersten Woche, 11,5 % zwischen acht Tagen und dem ersten Monat und noch einmal 20,2 % zwischen dem ersten Monat und dem ersten Lebensjahr. Daraus ergibt sich, dass nur ca. 65 % der Neugeborenen überlebten, während eine unglaublich hohe Prozentzahl von 35 % schon im ersten Lebensjahr starb. Setzen wir diese Zahlen ins vorige Schema (Abb. 3b), so ergibt sich, dass ein noch geringerer Prozentsatz aller Zygoten (9 %) die nächste Generation gesichert hat.

Die Reproduktionsrate menschlicher Bevölkerungen ist durch zahlreiche sehr komplexe Faktoren sowohl biologischer als auch sozialer und kultureller Art beeinflusst. Manche Bevölkerungen zeigen eine hohe Fertilitätsrate, die zu einem rapiden Zuwachs der Bevölkerungsgrösse führte. In dem meisten Ländern der westlichen Welt wurde in den letzten hundert Jahren eine starke Abnahme der Kinderzahl pro

Tab. 4. Prozentzahl der im ersten Lebensjahr verstorbenen Kinder in einer dörflichen Bevölkerung bei Ulm in der zweiten Hälfte des 19. Jahrhunderts

Geschlecht	Zahl der Geburten	Totgeburten	1 bis 7 Tage	8 Tg.bis 1 Monat	1 Monat bis 1 Jahr	Überlebende
M	686	6,0	3,7	12,9	22,9	60,8
F	674	3,7	3,1	10,2	17,5	69,1
M + F	1360	4,9	3,4	11,5	20,2	64,9

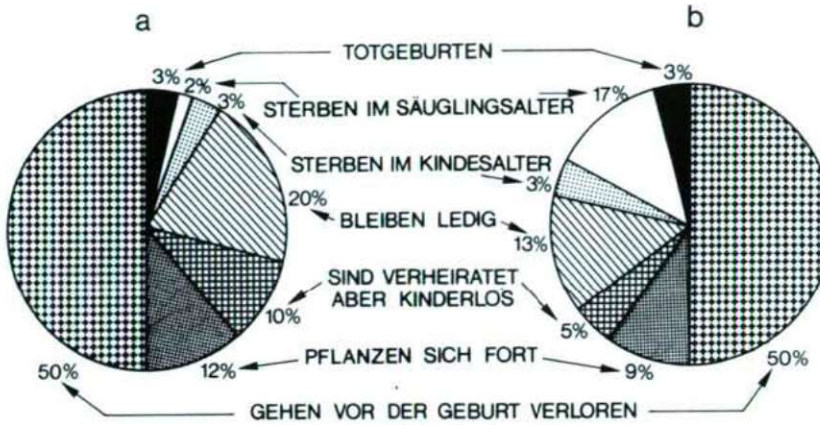


Abb. 3: Selektion in den rezenten Bevölkerungen a) 20. Jahrhundert
b) 19. Jahrhundert in Süddeutschland

Familie registriert. Auch hier ein Beispiel aus unseren eigenen Untersuchungen (Tab. 5). Mit Sicherheit ist der Geburtenrückgang vorwiegend auf den sozialen Druck unserer urbanisierten und technologisierten Gesellschaft zurückzuführen, aber nach NELSON und JURMAIN (1985) könnte auch eine biologische Komponente dazu beigetragen haben. Die Autoren fragen sich, ob der Geburtenrückgang nicht auch das Ergebnis eines veränderten Selektionsdrucks in unserer übervölkerten urbanen Umwelt sein mag.

Zweifellos haben sich die Verhältnisse in den heutigen Bevölkerungen durch ein besseres Gesundheitswesen, bessere Transportmöglichkeiten, Zunahme der

Tab. 5. Daten aus dem bio-demographischen Lebenslauf der Frau (nach STÄTTNER, 1984, und IMHOF, 1981)

	1840—1869	1945—1959	1972—1974
Lebensspanne von Frauen, die mindestens das heiratsfähige Alter erreicht haben (in Jahren)	64,2	73,5	76,5
Alter bei der Menarche (in Jahren)	16	14	12
Alter bei der Menopause (in Jahren)	45	49	51
Fruchtbare Jahre (in Jahren)	29	35	39
in % der Lebensspanne	45,2%	50%	51%
Anzahl der Kinder bzw. Geburten	7	3	1,53
Zeitraum zwischen Heirat und der letzten Geburt (in Jahren)	12,4	5,5	4,5
Zeit in % der Lebensspanne	19,3%	7,4 %	5,9%
Zeitraum zwischen 20. Geburtstag des letzten Kindes und Tod der Mutter (in Jahren)	2,9		29,1
Zeit in % der Lebensspanne	4,5%		38%

Bevölkerungsdichte, Auflösung der Isolate und starke Durchmischung der Bevölkerung verändert. Mit Sicherheit können aber Faktoren wie die übervölkerten Städte, die synthetische, oft unadäquate Ernährung, die Vielfalt psychologischer Stressituationen in unserer komplexen Gesellschaft wie auch die durch Umweltverschmutzung zunehmende Mutationsrate neue Formen von Selektionsdruck auslösen, und die menschliche Art muss sich ständig an die neue geschaffenen Umweltbedingungen anpassen.

Literaturverzeichnis

BENDER, K. (1983): Das HLA-System. 3. Aufl. — Biotest Diagnostics. Frankfurt(M).

DAMON, A. (1977): Human Biology and Ecology. — New York, W.W.Norton and Co.

EALES, L.J., NYE, K.E., PARKIN, J.M., WEBER, J.N., FORSTER, S.M., HARRIS, J.R.W. and PINCHING, A.J. (1987): Association of different allelic forms of group specific component with susceptibility to and clinical manifestation of human immunodeficiency virus infection. — Lancet, *8540*, 999—1002.

FREYE, N.A.(1986): Humangenetik. — Stuttgart, G. Fischer Verl.

FRIEDMAN, M.J. and TRAGER, W. (1981): The biochemistry of resistance to malaria. — Scientific American, *244*, 154—164.

GOULD, S.J. (1977): Evolution's erratic pace. — Nat. Hist., *86*, 12, 14, 16.

IMHOF, A. (1981): Die gewonnenen Jahre. — München, C.H. Beck Verl.

KNUSSMANN, R. (1980): Vergleichende Biologie des Menschen. — Stuttgart, G. Fischer Verl.

LIVINGSTONE, F.B. (1967): Abnormal hemoglobins in human populations. — Chicago, Aldine.

LIVINGSTONE, F.B. (1980): Natural selection and the origin and maintenance of standard genetic marker systems. — Yearbook Physic. Anthropol., 25—42.

LUZATTO, L. and BIENZLE, U. (1979): The malaria/G-6-PD hypothesis. — Lancet, *1*, 1183—1184.

MILLER, L.H., MASON, S.J., CLYDE, D.F. and MCGINNISS, M.H. (1976): The resistance factor to *Plasmodium vivax* in blacks: the Duffy-blood-group genotype, FyFy. — New Engl. J. Med., 295, 302.

MILLER, L.H., MASON, S.J., DVORAK, J.A., MCGINNISS, M.H. and ROTHMAN, I.K. (1975): Erythrocyte receptors for *(Plasmodium knowlesi)* malaria: Duffy blood group determinants. — Science, 189, 561.

MORTON, N.E. (1968): Problems and methods in the genetics of primitive groups. — Am.J.Phys.Anthropol., *28*, 191—202.

NELSON, H. and JURMAIN, R. (1985): Introduction to Physical Anthropology. — St.Paul, West Publishing Company.

PROKOP, O. und GÖHLER, W. (1986): Die menschlichen Blutgruppen. — Stuttgart, G.Fischer Verl.

RENNER, B. and SCHMIDT, H.D. (1986): Demography of the Steinheim Forest in the second half of the nineteenth century. II. Births. — Homo, *37*, 39—45.

STÄTTNER, I. (1984): Demographische Untersuchungen eines Isolats unter besonderer Berücksichtigung familienspezifischer Daten. — Ulm, Med.Diss.

STERN, C. (1968): Grundlagen der Humangenetik. — Jena, G.Fischer Verl.

SVEJGAARD, A., PLATZ, P. and RYDER, L.P. (1983): HLA and disease 1982— a survey. — Immunological Rev., *70*, 193.

VOGEL, F. und HELMBOLD, W. (1972): Blutgruppen-Populationsgenetik und Statistik. — in: Humangenetik, ein kurzes Handbuch. BECKER, P.E. (ed.), Vol. I/4. Stuttgart, Thieme Verl.

VOGEL, F. and MOTULSKY, A.G (1979): Human Genetics. — Berlin, Springer Verl.

ACTA BIOL. SZEGED. 34. PP. 133—138 (1988)

ONE POSSIBLE HYPOTHESIS OF THE MENARCHEAL SEASONALITY

GY. L. FARKAS

Department of Anthropology, Attila József University
H—6701 Szeged, P.O.B. 660. Hungary

(Received: August 31, 1988)

Abstract

The seasonal fluctuation of girls' menarche-age was observed more than fifthy years ago. It was supported by data collected in the most different countries in the world as well as in Hungary. However we can't find any reference to the interpretation of this phenomenon. Endocrinological researches performed the fact that melatonin produced in corpus pineale is in close connection with the circadian rhythm. At the same time the quantitative change of melatonin can also be brought into connection with the circannual rhythm of seasons. This observation refers to the fact that our sensivity for this rhythm developed in the course of evolution. On the basis of the menarche data of more then 32 thousand Hungarian girls the menarche sesonality can be connected with their circadian-circannual sensitivity.
Key words: menarche, seasonality, melatonin, light effect.

Introduction

Two very important processes taking place in a person's postnatal life, concerning their later fitting into society are: sexual and social maturation. A person's sexual maturation is a complicated process regulated by the neurohormonal system. Experimental research of healthy young people with a large number of samples can not be carried out because of several reasons, so the time of girls' first menstruation (menarche) was examined.

Material and methods

For our cross-sectional research we made questionnaires suitable for computer processing. The menarche questionnaire contained 32 questions, for example: occupation of parents, education level of parents, the crow-flight in km between the birthplaces of father and mother, the number of brothers and sisters of a girl, inhabitants of birthplaces of parents and girl, the birthorder of girl in the family, the type of school of girl (primary, secondary, vocational training school). Three of this questions were directly aimed at age at menarche: is or is not menarche of girl, the exact menarche time (year, month, day), is regulate the menstruation cycle or not.

There were 32156 girls — between 8—18 year old — in the sample. One half of the sample (16.000 girls) was been derived from county Csongrád (in Southern Hungary), with the remainder of the sample collected in the northern part of the country, in Transdanubia and in Eastern Hungary, as well (FARKAS, 1986).

Results

The median of sample is 12.79 years. Among our results, we now consider only the explanation of seasonal distribution of menarche.

The onset of first menstruation fluctuates with the seasons (Fig.1.). The most girls menstruated at first in January (13.1%), in August (11.8%), in July (10.5%) and in June (10.1%). The smallest relative frequency of menarche was in October (5.6%). Menarche had occurred in their mothers with the greatest relative frequency in May (14.9%), in June (12.8%) and in March (10.4%), the smallest realative frequency of menarche in their mothers was in December (5.7%) and in November (5.0%).

Discussion

In the literature dealing with menarche, several authors have pointed out that the occurrence of menarche varied over the twelve months of the calendar year.

Attention was first called to this by PELLER and ZIMMERMANN (1933) and was described by ENGLE and SHELESNYAK (1934) and VALŠIK (1934), as well. Following this, it was mentioned by several additional authors and we know only one author, who denied the existence of seasonal variability (WICH, 1965). Most opinions emphasize the greatest frequency in winter (BREIPOHL, 1938; VELISAVLJEV

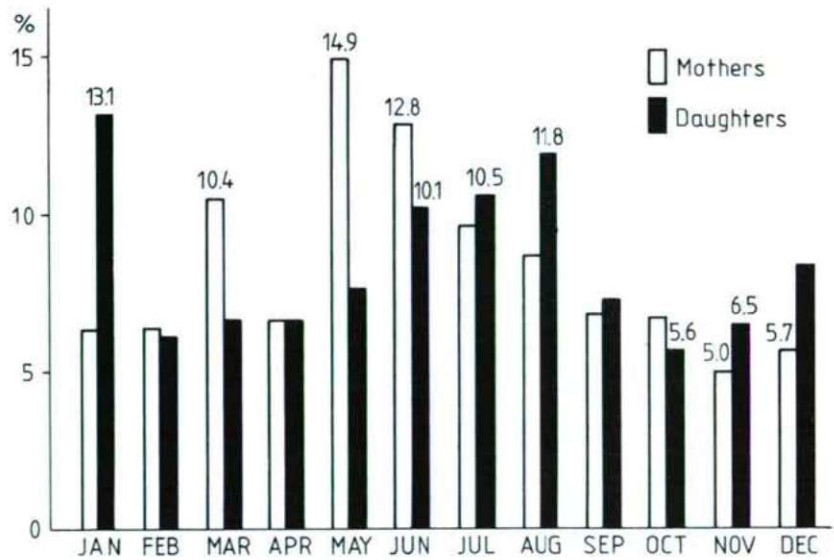


Fig 1. The relative frequency of menarche of mothers and their daughters according to months reported by FARKAS (1986)

and MESELDŽIJA, 1974; etc.). The occurrence of the greater peak in winter and the smaller one in summer is often mentioned (RICHTER, 1973; etc.). Some authors have only found a summer maximum (FARKAS, 1970; NECRASOV et al., 1964; WICH, 1965), while others have found a greater winter frequency and a smaller summer peak has occurred (DAMJANOVSKI and GAVRILOVIČ, 1978). According to same authors (HAJN and KOMENDA, 1982; VALŠIK, 1960) girls living in town show a winter maximum while girls living in the country show a summer maximum. Finally, some authors have observed a different maximum according to the late or early puberty of girls (ŠKERLJ, 1942). It is remakable that the some authors have published different results from the same country. These authors have made no attempt at finding an explanation for the seasonality of menarche.

In the following we call your attention to a possible explantion.

We start with the fact that we had earlier seen a correlation between menarche and the amount of light, e.g. number of sunny hours, average temperature, etc. (FARKAS, 1979). It has also been shown, that — as a consequence of the natural and artificial light — the pineal gland reacts with a decreasing melatonin production which then stimulated the process of pubescence (Fig.2.).

In the human organism, the melatonin concentration to the blood serum is high after birth until about the 8th year of life, supressing the occurrence of pubertas precox (ATTANASIO et. al., 1985). At the time of puberty the ratio of melatonin and sex hormones change in antagonistic ways (Fig.3.): the concentration of melatonin decreases while that of the hormones increases (SILMAN et al., 1979).

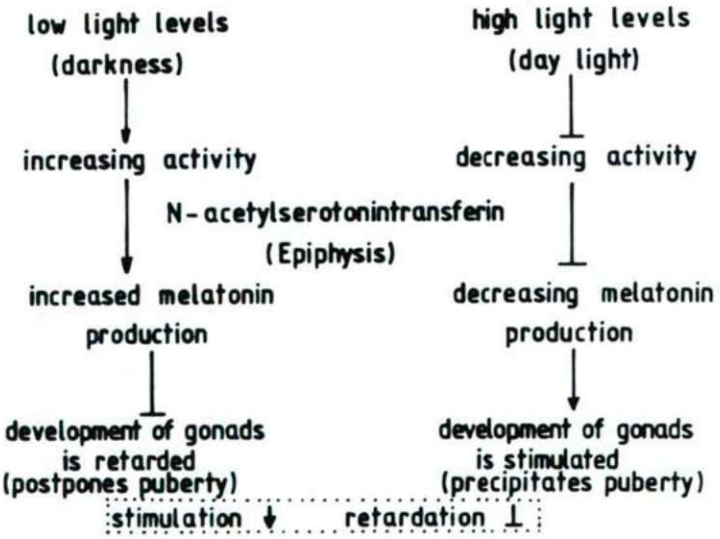


Fig 2. Connection between light levels and melatonin production

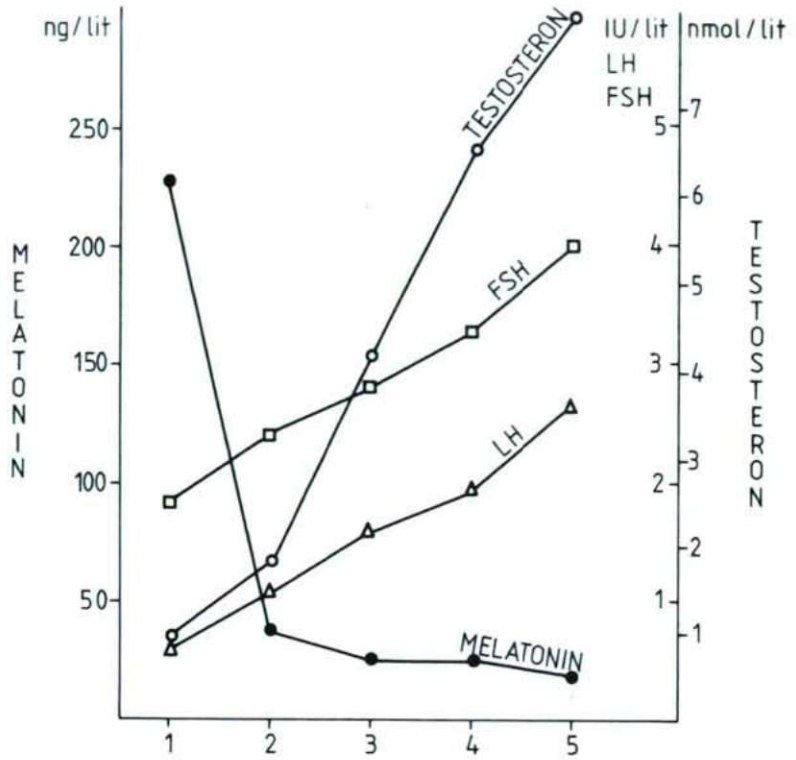


Fig 3. The connection between the change of sexual hormones and melatinon according to genital development stages (SILMAN et al. 1979)

At the same time, one reacts very quickly to the circadian changes of day and night. According to some authors the melatonin level in the blood serum is the highest at night between 1—3 o'clock (Fig.4.), while it decreases during the day (SMITH et al., 1981). In the same way, we see the circannual changes in Europe with a greater quantity of natural light in summer and a smaller quantity in winter.

With this knowledge, we may attribute the greater frequency of menarche in summer to the circannual rhythm. The winter peak however can not be explained in this manner and it may only be brought up as argument that the circadian-circannual sensitivity has developed in all living being and it is so strongly fixed that not even humans can get out of its way. This sensitivity however, may be artifically influenced (RADNÓT, 1953).

Under the influence of the night artificial illumination, melatonin production in the women decreases, which verifies the fact that melatonin formation is influenced by an increase in artifical light (WURTMAN et al., 1963).

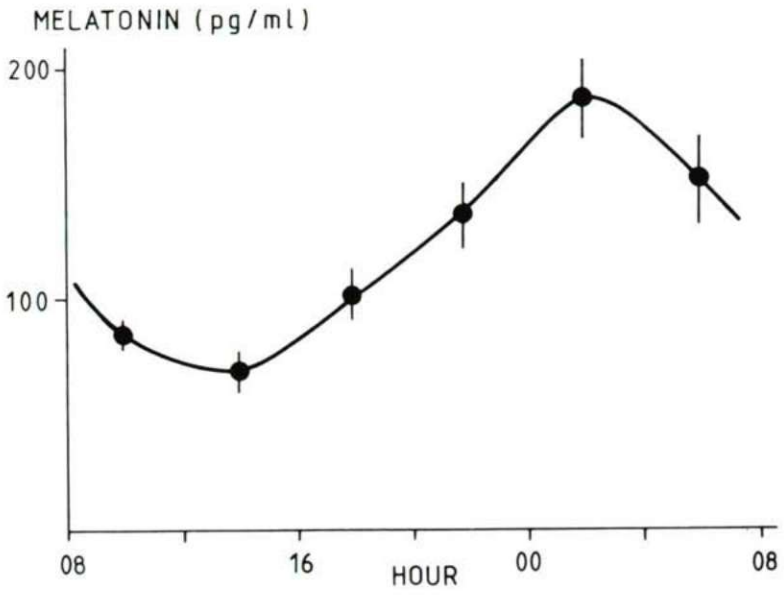


Fig 4. The circadian rhythm of melatonin production reported by VAUGHAN (1986)

Conclusions

In Hungary, television vieweing has increased in the last few decades, street and school illumination has become more modern and in short, the quantity of artificial light has increased. In this two decades the median decreased from 13.20 to 12.79 years in Hungary. The lower quantity of natural light in winter and spring has therefore been artifically increased. It is therefore possible that the greater frequency of the mother's menarche in March has been transferred in the case of their daughters to January.

It is, of course, not possible to interpret every observation in this way, because other socio-economical factors also have a role in this case. It remains however, without question that the connections mentioned here are based on objective facts.

At the same time, it is evident that the role of the pineal gland in the pubescence of humans is much more important then it was previously thought.

As shown by experiences we may also conclude — possessing other experimental results — to physiological process of puberty by the indirect method.

References

ATTANASIO, A., BORELLI, P. and GUPTA, P. (1985): Circadian rhythms in serum melatonin from infancy to adolescene. — Journal of Clinical, Endocrinological Metabolism, *61*, 388—390.

BREIPOHL, W. (1938): Über die Beziehung der juvenilen Ovarialfunktion zu klimatischen Faktoren. — Archiv für Gynäkologie, *166*, 202—204.

DAMJANOVSZKI, J. and GAVRILOVIC, Ž. (1978): The occurence of menarche in school girls from Kumanovo and sorrounding area. Prvi jugoslovenski simpzijum o menarhi, Beograd, 229—235.

ENGLE, E.T. and SHELESNYAK, M.C. (1934): First menstruation and subsequent menstrual cycles of pubertal girls. — Human Biology, *6*, 431—453.

FARKAS, GY. (1970): Neuere Angaben zur Pubertät der tiefländischen Mädchen. — Acta Biol. Szeged. *16*, 109—115.

FARKAS, GY. (1979): Die Grösse der Menarche-Mediane in Ungarn und die meteorologischen Angaben. — Ärztliche Jugendkunde, *70*, 274—281.

FARKAS, GY. (1986): Somatic development and age at menarche of 10—18 year old girls of Southern Hungary (in Hung.). Szeged.

HAJN, V. and KOMENDA, S. (1982): Menarche der Mädchen aus Olomouc, ihrer Schwestern und Mütter. —Anthropologie, *20*, 163—176.

NECRASOV, O., CRISTESCU, M., BULAI, M. and FEODOROVICI, C. (1964): Etudes sur la croissance et le développement des enfants en R.P.R. L'age de la puberté chez les jeune filles de Piatra Neamt. — An.Sci.Univ. Iasi.

PELLER, S. und ZIMMERMANN, J. (1933): Über Faktoren welche die Zeit der Erstmenstruation bestimmen. — Zentrallblatt für Gynäkologie, *57*, 2897—2909.

RADNÓT, M. (1953): A megvilágítás jelentősége a gonádok működésében. —Orvosi Hetilap, *10*, 262.

RICHTER, J. (1973): Zur Akzeleration der Menarche, Ergebnisse und Schlussfolgerungen aus Untersuchungen an Görlitzer Mädchen. — Ärztliche Jugendkunde, *64*, 268—280.

SILMAN, R.E., LEONE, P.M., HOOPER, R.L. and PREECE, M.A. (1979): Melatonin, the pineal gland and human puberty. — Nature, *282*, 301—303.

ŠKERLJ, B. (1942): Die Menarche von Gymnasiatinnen aus Ljubjana (Laibach). — Zeitschrift für Rassenkunde, *13*, 17—25.

SMITH, J.A., O'HARA, J. and SCHIFF, A.A. (1981): Alterned diural serum melatonin rhythm in blind men. — Lancet, *2*, 933.

VALŠIK, J.A. (1934): Ve které ročni době objevuje se první menstruaceé. — Casopis lékařů ceských, *73*, 1000—1001.

VALŠIK, J.A. (1960): Über jahreszeitliche Schwankungen im Menarchebeginn in Bratislava. — Acta Facultatis Rerum Naturalium Universitatis Comenianae, Anthropologia, *4*, 489—502.

VAUGHAN, G.M. (1986): Human melatonin in physiologic and diseased states: neural control of the rhythm. — Journal Neural Transm. *21*, 203.

VELISAVLJEV, M. and MESELDŽIJA, D. (1974): O menarchi učenica osnove škole u Botošu i Despotovcu. — Glasnik ADJ, *12*, 81—85.

WICH, J. (1965): Pigmentation of eyes and hair, frequency of birth, season and age of first appearance of menarche. — Przeglad Antropologiczni, 31, 293—298.

WURTMAN, R.J., AXELROD, J. and PHILIPS, L.S. (1963): Melatonin synthesis in the pineal gland: control by light. — Science, *142*, 1071—1073.

ACTA BIOL. SZEGED. 34. PP. 139—153 (1988)

HEAD MEASUREMENT PARAMETERS AT 23338 3 TO 18 YEARS OLD HUNGARIAN CHILDREN

GY. L. FARKAS[1] AND K. NYILAS[2]

[1]*Department of Anthropology, Attila József University, Szeged, H—6701, P.O.B. 660;* [2]*Department of Zoology, György Bessenyei College of Education, Nyíregyháza, H—4400, Hungary*

(Received: January 31, 1988)

Abstract

The authors studied 3—18 agers' head measurements in four different regions of Hungary (in the towns of Szeged and Békéscsaba and in the counties of Nógrád and Szabolcs) between 1958—1984. In the case of 10953 boys and 12385 girls they examined the maximum head lenght, the greatest head breadth, the bizygomatic breadth, the total face height, the total head height, the head circumference, the cephalic index, the facial index, the transversal cephalo-facial index.

In this publication they will expose the most important parameters (sample size, arithmetic mean, standard deviation and range) of the above mentioned measurements and indexes for the whole sample as well as for the subsample of Szeged, not published yet.

Concerning the above mentioned age-groups, the pooled sample is the result of the largest till now collection of data in Hungary.

It was stated that no statistically significant differences could be observed between the absolute head measurements of children living in different regions, while at some indexes variances were significant.

Key-words: 3—18 agers, Hungarian children, head measurements, indexes.

Introduction

The development of science called forth the use of more up-to-date methods in researches in anthropology/human biology. By means of these methods, (serological, population genetical and human genetical) new information about a certain population can be obtained. Simultaneously, the so called classical investigating methods, like anthropomethry, were slighty overshadowed in some fields of research work. That applies particularly to young Hungarian age-groups, where investigators, on collecting auxological data, concentrated essentially on physical development changes and neglected head measurements.

First data about Hungarian childrens' head measurements were published some eighty years ago. At first observations concerned only the head circumference (KÓCZIÁN, 1910; KONRÁDI, 1911), later they were extended to other head measurements as well (BALLAI, 1918, 1923, 1929; TÖRÖK, 1913; TUSZKAI, 1911). In Hungarian anthropological literature new data about children's head measurements can be found some ten years later (BARTUCZ, 1938; LIPP, 1938). During the following fifteen years no articles on this subject were published by Hungarian anthropolo-

gists (MALÁN, 1947). Although NEMESKÉRI studied ten head measurements and seven indexes with boys and girls in the Ivád inbreeding between 1939 and 1950, their parameters — especially by pooled age-groups — appeared only later (NEMESKÉRI, 1953).

Researches subsequent to the second world war were run either about healthy children's head measurements (DEZSŐ, 1967; EIBEN, 1967; EIBEN and PANTÓ, 1984; HEGYI and TÖRÖK, 1968; NYILAS, 1980, 1982a, 1982b, 1983, 1984, 1987; NYILAS and NYILASNÉ, 1985; PALIK, 1965; RAJKAI, 1967; SZÉNÁSY, 1971) or only about certain head characteristics (DOBÁNY, 1958; VÁGÓ, 1965). Among these publications highly prominent are RAJKAI's results from longitudinal data (RAJKAI, 1967).

The other part of researches aimed chiefly at studying handicapped children's head measurements (BUDAY, 1978a, 1978b; SZABÓ, 1982; SZILÁGYI, 1968, 1972) or at determining a relationship between pathological anomalies and head measurements (SZÉNÁSY, 1968).

The few items in Hungarian literature concerning juvenile changes in head measurements prove that a lot of various head measurements in large samples of Hungarian children have not been studied yet. This is apparently the cause of the lack of treatment of changes in head measurements in Hungarian text books dealing with young people's physical education, destined for medical superintendents of schools (ÁGFALVI, 1987; KAROSSA—PFEIFFER and MELLY, 1959). References of this kind can only be found in the vade-mecum meant for pediatricians and what is more, they are based on observations carried out in America in the 1940's and thus are scarcely acceptable when drawing conclusions for Hungarian children.

All these facts led us to set the aim to study Hungarian children's head measurements in a large sample.

Material and method

At first, the authors of the present publication started to collect data independently. Thus head measurements also were observed when examining pupils in Szeged (South Hungary) in the academic year of 1958/1959 (FARKAS, 1961), the evaluation results remaining unpublished. Afterwards, one of the authors engaged a large collection of data in the county of Szabolcs—Szatmár (North-East Hungary) including nursery school children (NYILAS, 1980, 1982a, 1982b, 1983, 1984, 1987; NYILAS and NYILASNÉ, 1985). This was followed by a common collection of data by both FARKAS and NYILAS in the town of Békéscsaba in 1983 (South-East Hungary) and in the county of Nógrád (North Hungary). The results of the latter collection of data were published (NYILAS, 1980, 1982a) and partly are going to be printed (FARKAS in press) While the four samples pooled data are beeng communicated right now.

Figure 1. shows geographical location of sample areas.

Table 1. indicates the sample size. The number of examined boys was 10953, of the girls 12385. Their distribution is variable according to sample areas, the bulk of observation having been carried out in the county of Szabolcs while the least in the county of Nógrád.

The age-groups examined in the different areas vary, too, since only two out of the four subsamples — in the county of Szabolcs and in the town of Békéscsaba — include nursery school children's measurements.

In spite of these restrictions we are convinced that the sample size by age-groups and sexes enables us to draw relevant conclusions.

Fig 1. Distribution of sample areas in Hungary

Table 1. Distribution of sample according to sample areas, years of examination, sexes and age-groups

Boys					Age	Girls				
Szeged 1958—1959	County Szabolcs 1975—1978	Békés-csaba 1983	County Nógrád 1984	Together		Szeged 1958—1959	County Szabolcs 1975—1978	Békés-csaba 1983	County Nógrád 1984	Together
—	46	89	—	135	3	—	53	77	—	130
—	49	139	—	188	4	—	52	155	—	207
—	49	168	—	217	5	—	50	164	—	214
8	125	190	—	323	6	—	89	180	—	269
90	597	119	—	806	7	77	553	123	—	753
150	718	128	—	996	8	165	734	119	—	1018
186	705	128	—	1019	9	156	690	166	—	1012
189	688	98	—	975	10	150	776	135	—	1061
171	764	103	93	1131	11	130	822	156	95	1203
207	808	102	162	1279	12	169	767	153	144	1233
187	757	114	149	1207	13	117	795	145	152	1209
148	778	126	165	1217	14	221	712	236	139	1308
212	227	115	100	654	15	273	193	443	156	1065
120	—	112	58	290	16	200	—	374	147	721
149	—	91	59	299	17	152	—	310	139	601
101	—	69	47	217	18	78	—	189	114	381
1918	6311	1891	833	10953	Total	1888	6286	3125	1086	12385

As it has been mentioned above data of one out of the four sample areas (county of Szabolcs) were alr eady published while young people's parameters from Békéscsaba will appear in a next publication (FARKAS, in press). There were only a few children examined in the county of Nógrád thus their parameters will not be given separately. In the following we are giving the parameters both by sexes and indexes for the whole sample (Tables 2 to 10), what can be considered as standards for Hungary. As to children of Szeged, their parameters will also be given separately according to the mentoined points of view (Tables 11 to 19).

The evaluation was made on R-55 type computer by the László Kalmár Cybernetic Laboratory of Attila József University. As differences between arithmetic means were difficult to determine on the basics of six month' age-group schemes, the whole sample was analysed according to one year age-group schemes. On settling the age the decimal table of IBP was taken in account.

The following measurements and indexes were determined making use of the Martin-Saller method (MARTIN and SALLER, 1956): maximum head lenght, greatest head breadth, minimum forehead breadth, total head height, head circumference, total face height, bizygomatic breadth, cephalic index, total facial index, transversal cephalo-facial index.

Results

The examined head and face measurements growth proceeds —with slinght shifts — at nearly the same rate as the height growth.

The averages of different regions show no essential differences between the same age-groups, what is a result confirmed by significance tests.

Table 2. Parameters of maximum head lenght (g-op). — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
135	171.63	6.91	157—190	3	129	166.17	5.52	152—177
188	171.13	6.76	153—192	4	207	167.87	6.19	154—183
217	174.18	7.37	152—196	5	214	168.80	6.74	146—187
323	173.01	7.86	146—194	6	269	169.41	6.48	150—190
805	169.98	6.65	147—196	7	753	166.68	6.65	147—188
996	171.20	6.23	147—194	8	1016	168.12	5.95	140—196
1019	172.01	6.10	151—194	9	1012	169.50	5.94	141—187
975	173.47	6.15	151—196	10	1061	170.25	6.44	150—198
1129	174.41	6.53	152—200	11	1200	171.83	6.20	146—196
1278	176.32	6.47	153—200	12	1229	173.48	6.05	155—208
1207	176.94	6.20	160—200	13	1209	174.73	5.81	158—202
1214	178.78	6.92	154—205	14	1308	175.65	6.79	144—198
654	181.89	7.08	161—207	15	1065	178.56	6.02	159—196
290	187.14	6.67	171—206	16	720	180.23	6.22	156—200
298	188.32	6.34	171—205	17	598	180.08	6.48	164—204
215	188.21	6.97	166—210	18	380	179.63	6.21	162—200
10943					12370			

In the case of the cephalic index a great similarity exists between children living in the county of Szabolcs and those living in Szeged. Children living in Békéscsaba and Nógrád fall behind the values of Szabolcs and those of the pooled sample with 2 to 5 index rates.

Total face index and transversal cephalo-facial index averages clearly illustrate that in spite of the hardly perceptible variances in the absolute head measurements there are differences in the head form of children living different areas and administrative districts of Szabolcs. These differences are more important with girls than with boys. Averages of children living in Szeged, Békéscsaba and county Nógrád exceed by 1 to 2 index units in the case of boys, and 2 to 4 index units in the case of girls those living in Rétköz (part of the county of Szabolcs) or in Szabolcs.

Since the sample size exceeds 10000 both in the case of boys and girls, we are deeming that the obtained averages are characteristic for young Hungarian people who are now 6 to 18 years old.

Table 3. Parameters of greatest head breadth (eu-eu). — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
134	139.09	5.90	123—153	3	130	134.83	6.62	118—149
188	140.32	6.19	128—158	4	270	136.22	5.57	125—148
217	141.86	6.36	127—158	5	214	138.46	5.32	122—153
323	144.32	5.80	129—161	6	269	140.11	5.76	124—155
806	146.62	5.69	130—170	7	752	142.71	5.54	123—171
996	147.63	5.53	125—170	8	1015	144.09	5.70	123—161
1017	148.48	6.35	121—165	9	1011	144.45	6.28	120—165
975	149.83	5.49	130—167	10	1060	146.28	5.46	120—175
1130	150.19	6.74	120—169	11	1203	146.69	6.13	120—173
1279	151.23	5.89	125—167	12	1230	147.82	5.59	123—164
1207	152.02	6.15	122—169	13	1209	148.64	6.22	123—168
1215	152.92	6.67	120—172	14	1306	149.39	6.42	122—174
653	154.75	5.84	136—175	15	1065	151.24	5.53	134—173
290	156.08	5.86	137—170	16	721	152.23	5.36	136—168
297	157.73	6.02	140—171	17	596	152.08	5.80	132—169
216	157.72	5.82	141—173	18	380	152.03	5.49	138—167
10943					12368			

Table 4. Parameters of bizygomatic breadth (zy-zy). — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
130	112.69	4.39	100—122	3	130	109.05	4.44	97—118
188	113.91	5.29	102—125	4	204	111.61	4.34	100—122
217	116.27	4.95	100—132	5	214	113.84	4.73	100—123
324	118.44	5.39	103—136	6	269	116.35	5.16	102—127
806	121.19	5.70	95—141	7	752	118.29	5.81	101—136
995	122.37	5.32	102—142	8	1017	120.13	5.59	94—146
1017	123.38	6.39	93—146	9	1010	121.62	5.94	92—141
973	125.01	5.79	103—143	10	1060	123.48	5.53	103—142
1130	126.15	6.53	91—148	11	1203	124.63	6.17	100—147
1279	128.09	5.57	100—148	12	1232	126.93	5.83	102—150
1207	129.80	6.01	106—148	13	1211	128.68	5.97	98—148
1212	131.67	6.94	98—162	14	1305	129.90	6.83	97—152
653	134.93	5.93	115—156	15	1065	132.67	5.39	109—155
291	137.17	6.05	116—154	16	720	134.39	4.82	120—152
297	139.23	5.31	123—154	17	598	134.74	4.99	120—151
217	139.77	5.42	127—157	18	380	134.62	4.55	124—150
10936					12370			

Table 5. Parameters of total face height (n-gn). — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
134	85.18	3.76	77—97	3	128	81.67	4.61	73—92
187	86.59	4.29	80—97	4	206	84.46	4.98	73—98
217	89.47	4.34	79—100	5	214	87.58	4.45	78—100
324	92.23	5.94	72—118	6	269	90.60	5.01	77—106
806	93.49	6.06	69—119	7	749	90.81	5.93	78—120
994	95.38	5.71	78—116	8	1018	92.64	5.61	78—119
1020	97.35	6.02	81—119	9	1010	95.04	5.85	80—133
974	99.23	6.04	81—120	10	1061	97.01	5.73	67—118
1128	100.83	6.00	84—126	11	1203	99.06	6.33	78—122
1278	102.60	6.22	81—128	12	1232	101.45	5.98	86—126
1207	104.73	6.34	80—128	13	1211	103.75	6.13	83—128
1216	108.09	7.10	81—130	14	1308	105.26	5.90	81—144
652	111.35	6.53	86—132	15	1066	106.76	5.48	87—124
291	114.82	6.72	95—134	16	717	107.60	5.23	93—123
297	116.08	5.98	101—133	17	599	107.77	5.74	75—124
216	117.35	6.26	101—135	18	381	107.35	5.49	90—122
10941					12372			

Table 6. Parameters of total head height (gn-v). — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
135	184.18	8.76	163—207	3	127	179.50	8.22	159—197
187	188.43	9.56	153—209	4	204	183.43	9.55	163—213
216	191.45	7.73	167—211	5	214	186.59	8.99	163—204
324	195.64	10.44	168—231	6	269	190.10	8.21	166—220
805	193.49	12.38	154—229	7	751	188.41	11.00	145—220
996	193.80	11.44	161—235	8	1016	190.08	9.90	159—220
1017	196.31	11.13	163—228	9	1013	192.07	10.07	158—222
974	197.91	11.86	160—234	10	1060	193.21	10.82	159—227
1127	200.74	11.22	163—240	11	1197	196.79	11.30	163—232
1278	202.40	10.36	168—232	12	1231	197.74	10.85	163—235
1205	205.05	10.89	168—241	13	1208	201.09	10.59	153—238
1210	209.43	11.45	176—250	14	1308	203.08	9.94	166—238
650	216.54	10.65	172—238	15	1064	202.59	9.71	161—230
290	216.54	9.97	182—243	16	721	202.91	9.66	174—230
296	217.98	10.33	189—247	17	601	203.13	9.14	174—231
217	219.78	9.72	184—243	18	379	202.05	9.53	174—227
10927					12363			

Table 7. Parameters of head circumference. — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
89	499.08	12.74	472—536	3	77	483.44	13.59	443—512
137	500.60	12.54	472—539	4	158	489.96	12.22	458—525
168	508.87	14.03	463—552	5	165	493.73	13.29	436—528
199	512.35	12.94	475—547	6	176	500.02	12.01	468—537
207	512.61	13.64	473—555	7	195	505.28	13.45	468—547
278	516.91	12.98	481—560	8	283	507.00	12.81	470—549
314	520.60	12.99	482—563	9	322	512.83	12.05	473—547
286	523.72	13.62	490—557	10	284	515.86	13.80	477—556
366	528.01	14.10	492—576	11	381	520.24	14.47	471—563
470	532.20	14.23	482—577	12	465	524.93	14.87	482—566
450	536.28	14.22	488—573	13	415	531.34	13.79	485—567
437	545.24	15.64	486—598	14	593	536.32	14.11	459—578
423	550.91	16.02	490—590	15	869	540.70	13.94	500—583
290	558.91	15.60	516—596	16	718	542.85	13.43	502—589
297	564.27	14.45	526—601	17	598	543.28	14.63	492—588
216	565.50	15.68	512—608	18	378	541.63	13.73	492—584
4627					6077			

Table 8. Parameters of cephalic index. — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
134	80.96	4.98	69—91	3	129	80.87	5.06	68—93
188	81.76	5.06	69—95	4	207	80.92	4.78	70—92
217	81.32	5.25	70—95	5	214	84.33	5.63	68—96
322	83.15	5.23	70—97	6	269	82.90	5.68	70—95
805	85.87	4.18	72—98	7	752	85.22	4.28	71—102
996	85.83	4.11	71—97	8	1014	85.28	4.17	67—98
1016	85.90	4.22	71—98	9	1011	84.82	4.34	70—102
974	85.95	3.80	71—99	10	1060	85.51	3.84	70—98
1128	85.71	4.30	69—99	11	1200	84.95	4.12	70—100
1278	85.36	4.05	70—101	12	1226	84.76	3.63	72—97
1206	85.49	3.94	68—97	13	1206	84.64	3.80	68—98
1213	85.11	3.92	70—99	14	1306	84.65	3.81	68—97
653	84.66	3.65	73—96	15	1064	84.28	3.62	71—98
289	83.00	3.72	73—93	16	720	84.07	3.89	72—99
296	83.32	3.76	72—93	17	594	84.07	3.92	72—95
214	83.38	3.85	72—93	18	379	84.22	4.01	72—97
10929					12351			

Table 9. Parameters of facialindex. — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
129	75.65	4.25	68—87	3	128	74.84	4.22	64—84
187	75.75	4.13	67—87	4	203	75.38	4.06	66—87
217	76.88	4.16	65—90	5	214	76.31	3.88	65—87
324	77.55	5.37	62—102	6	269	77.85	4.56	68—97
806	76.76	5.37	56—111	7	748	76.39	5.05	62—104
993	77.55	4.96	60—104	8	1017	76.72	4.96	64—106
1017	78.58	5.36	64—110	9	1007	77.81	5.37	57—107
971	78.98	5.10	65—101	10	1060	78.18	4.88	54—99
1127	79.61	5.95	65—113	11	1203	79.13	5.58	63—108
1278	79.66	4.86	66—107	12	1231	79.54	4.95	66—114
1206	80.25	4.66	61—101	13	1210	80.26	5.15	64—106
1211	81.70	5.02	66—108	14	1305	80.70	5.14	64—110
651	82.08	4.48	67—95	15	1064	80.06	4.12	66—97
291	83.30	5.05	69—99	16	716	79.64	4.15	68—91
295	82.94	4.48	71—94	17	596	79.55	4.52	57—95
216	83.55	5.20	69—98	18	380	79.31	4.26	67—92
10919					12351			

Table 10. Parameters of transversal cephalo-facial index. — Total

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
84	79.71	2.53	73—87	3	77	80.53	3.04	74—89
139	80.65	2.28	73—87	4	152	81.55	2.78	76—92
168	81.11	2.74	73—89	5	164	81.99	2.84	72—90
280	81.66	3.25	69—90	6	223	82.24	2.93	70—89
806	82.20	3.02	61—94	7	751	82.44	3.13	68—94
995	82.45	3.00	70—96	8	1014	82.94	3.28	67—96
1014	82.64	3.22	67—95	9	1009	83.75	3.02	71—97
972	82.97	3.20	66—95	10	1059	83.96	2.77	71—96
1129	83.58	3.56	60—96	11	1203	84.52	3.25	68—98
1279	84.25	2.91	72—95	12	1229	85.41	2.86	74—95
1206	84.92	2.95	74—98	13	1208	86.11	2.98	75—98
1211	85.61	3.17	73—101	14	1303	86.50	3.13	73—98
652	86.71	2.88	74—98	15	1063	87.28	2.91	75—97
290	87.41	2.93	78—96	16	720	87.84	2.88	79—100
295	87.81	3.15	78—97	17	595	88.11	2.74	80—97
216	88.19	3.00	80—96	18	379	88.11	2.69	80—96
10736					12149			

Table 11. Parameters of maximum head length (g-op). — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	167.63	5.81	159—177	6	—	—	—	—
90	171.26	6.67	157—196	7	77	167.52	5.89	156—184
150	172.45	5.51	158—185	8	163	168.17	5.34	155—183
186	174.13	5.96	158—194	9	156	170.31	5.36	155—184
189	175.13	6.02	160—192	10	150	170.51	5.49	157—184
169	176.12	6.12	164—194	11	130	172.53	6.12	156—191
207	177.38	6.36	153—199	12	168	173.94	5.61	160—188
187	178.99	5.42	163—192	13	117	175.00	5.59	159—188
147	181.39	6.10	163—200	14	221	178.12	5.73	167—195
212	182.95	6.14	167—200	15	273	178.48	5.31	165—192
120	185.78	5.97	171—202	16	199	179.61	5.93	156—196
149	187.21	5.68	175—201	17	150	180.00	6.35	164—197
100	187.71	5.88	166—202	18	77	178.71	4.97	166—194
1914					1881			

Table 12. Parameters of greatest head breadth (eu-eu). — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	148.13	5.92	143—159	6	—	—	—	—
90	148.17	5.02	136—163	7	77	145.23	4.88	132—156
150	149.39	5.27	137—161	8	163	146.32	5.05	131—161
187	150.75	5.09	138—165	9	156	148.08	4.96	134—160
189	151.25	4.73	141—165	10	150	148.92	4.55	136—161
171	152.18	4.99	139—165	11	130	149.48	4.82	136—161
207	152.79	5.79	135—166	12	169	150.04	4.71	137—162
187	152.99	5.22	140—169	13	118	150.75	5.19	138—165
146	154.10	4.74	144—167	14	219	152.25	5.23	138—169
212	154.92	5.72	141—169	15	274	152.25	5.01	138—173
121	155.69	5.79	137—170	16	200	153.18	4.95	136—168
148	158.15	5.22	145—171	17	149	153.68	4.69	142—165
100	158.14	5.86	145—173	18	77	153.75	5.00	142—165
1916					1882			

Table 13. Parameters of bizygomatic breadth (zy-zy). — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	120.38	4.31	111—126	6	—	—	—	—
90	122.53	5.26	110—136	7	76	121.04	4.70	112—131
150	122.81	4.72	108—135	8	164	121.52	5.43	102—138
186	124.41	5.20	107—140	9	155	124.65	5.61	113—141
187	126.28	4.83	115—138	10	149	124.79	5.25	112—139
170	127.61	4.96	113—140	11	130	127.07	5.14	115—141
207	128.38	5.34	112—141	12	169	128.00	5.42	114—141
186	129.92	5.23	118—143	13	117	130.15	5.41	114—142
147	132.22	5.06	118—146	14	220	131.90	5.31	114—148
211	134.33	5.53	119—151	15	273	132.89	5.17	117—146
121	135.62	6.01	120—151	16	199	134.53	5.09	123—149
148	137.89	5.21	123—150	17	137	135.28	4.68	122—146
101	138.22	5.37	127—157	18	77	134.83	4.87	124—150
1912					1866			

Table 14. Parameters of total face height (n-gn). — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	93.75	3.58	89—99	6	—	—	—	—
90	92.88	4.82	82—103	7	75	89.61	4.54	78—104
150	94.57	4.40	83—108	8	165	90.89	4.40	81—102
187	95.98	5.03	83—109	9	156	93.71	4.70	81—107
189	97.66	4.84	86—109	10	150	95.28	4.22	86—106
171	99.01	5.01	84—112	11	130	97.52	5.45	84—111
206	101.35	5.34	89—118	12	169	98.98	5.67	86—113
187	103.05	6.04	80—116	13	117	100.92	4.83	89—111
148	107.28	7.11	92—130	14	221	104.94	5.12	93—118
211	112.93	6.70	94—132	15	273	106.58	5.51	87—122
121	116.35	7.06	96—133	16	196	108.27	5.40	93—122
148	116.93	5.63	102—132	17	150	109.05	5.47	96—122
100	118.96	5.96	102—133	18	78	108.27	5.35	98—121
1916					1880			

Table 15. Parameters of total head height (gn-v). — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	180.50	6.40	168—186	6	—	—	—	—
90	180.67	8.67	160—202	7	76	178.97	8.35	163—195
150	182.55	7.79	161—207	8	163	180.85	7.74	162—205
186	185.47	7.75	166—215	9	157	183.94	7.74	160—203
188	187.67	8.54	166—210	10	149	185.23	7.54	163—203
171	190.98	8.68	169—214	11	130	187.84	8.52	166—209
206	194.53	9.26	168—223	12	169	190.14	9.07	164—218
187	196.17	9.19	170—221	13	118	191.60	7.65	170—212
147	201.88	11.18	176—230	14	221	195.75	8.69	166—217
209	212.19	11.77	172—236	15	272	195.68	8.50	173—220
121	217.10	10.34	182—243	16	200	196.60	8.83	174—218
148	217.71	9.52	194—244	17	152	198.92	8.03	183—225
101	219.95	9.46	184—238	18	78	197.83	7.76	178—217
1912					1885			

Table 16. Parameters of head circumference. — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	501.63	11.60	487—520	6	—	—	—	—
90	509.46	12.83	480—543	7	76	503.38	11.87	470—530
150	514.59	12.36	481—552	8	165	506.53	12.59	470—542
186	519.19	12.35	487—563	9	156	512.06	11.41	473—542
189	521.30	12.99	490—551	10	149	514.02	13.26	480—548
170	525.08	13.62	492—568	11	130	519.22	14.58	481—559
206	530.12	14.73	482—571	12	169	522.61	13.60	482—560
187	533.20	12.62	499—562	13	118	526.90	13.74	485—562
147	540.64	14.27	505—580	14	220	536.14	14.17	505—578
210	548.57	15.65	490—590	15	273	540.07	13.79	502—578
121	557.53	15.25	516—594	16	197	543.53	13.28	510—578
149	563.21	15.29	527—601	17	150	544.79	15.29	505—585
100	565.62	15.55	516—598	18	75	541.41	11.68	517—565
1913					1878			

Table 17. Parameters of cephalic index. — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	87.88	3.83	84—95	6	—	—	—	—
90	86.19	4.50	72—98	7	77	86.29	3.84	77—97
150	86.17	3.78	77—97	8	162	86.55	3.80	72—96
186	86.15	4.02	78—98	9	156	86.55	3.79	77—98
189	85.95	3.50	77—98	10	150	86.93	3.39	79—96
169	86.02	3.69	77—96	11	130	86.22	3.22	79—95
207	85.73	3.77	75—95	12	168	85.80	2.97	78—93
187	85.06	3.30	78—93	13	117	85.79	3.37	78—94
146	84.54	3.45	75—93	14	219	85.05	3.30	75—97
212	84.25	3.41	77—94	15	273	84.85	3.16	78—95
120	83.45	3.69	74—93	16	199	84.85	3.51	75—99
148	84.01	3.08	77—93	17	147	84.97	3.44	76—94
99	83.79	3.27	76—92	18	76	85.47	3.10	77—92
1911					1874			

Table 18. Parameters of facialindex. — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	77.63	3.66	74—84	6	—	—	—	—
90	75.41	4.09	65—83	7	74	73.70	4.10	63—83
150	76.59	3.78	66—86	8	164	74.40	4.14	64—88
186	76.76	4.32	64—93	9	154	74.84	4.24	65—87
187	76.98	4.40	66—89	10	149	75.96	4.01	67—86
170	77.19	4.43	65—89	11	130	76.32	4.16	66—89
206	78.52	4.07	69—88	12	169	76.89	4.18	67—90
186	78.84	4.49	61—89	13	116	77.17	4.09	67—88
147	80.73	4.51	69—93	14	220	79.18	4.34	70—92
210	83.58	4.53	72—95	15	272	79.83	4.43	66—97
121	85.36	4.99	71—99	16	195	80.06	4.23	68—91
147	84.34	4.27	73—94	17	148	80.14	4.46	71—92
100	85.60	4.69	76—98	18	77	79.90	4.39	71—91
1908					1868			

Table 19. Parameters of transversal cephalo-facial index. — Sample of Szeged

Boys				Age	Girls			
n	$\bar{x}$	s	w		n	$\bar{x}$	s	w
8	80.88	2.70	77—84	6	—	—	—	—
90	82.22	2.82	75—89	7	76	82.91	2.94	78—90
150	81.77	2.68	75—88	8	162	82.63	3.46	67—96
186	82.07	2.94	73—90	9	155	83.68	3.02	77—94
187	83.01	2.91	75—91	10	149	83.32	2.79	75—90
170	83.41	2.72	76—90	11	130	84.52	2.94	77—91
207	83.59	2.90	74—91	12	169	84.83	2.71	77—92
186	84.50	2.79	76—96	13	117	85.80	2.78	79—94
146	85.30	2.72	78—92	14	218	86.23	2.69	75—96
211	86.23	2.83	79—93	15	273	86.84	2.91	76—95
121	86.63	2.94	78—93	16	199	87.38	3.05	79—97
147	86.74	2.89	78—93	17	149	87.60	2.77	80—94
100	86.96	2.60	80—93	18	76	87.18	2.87	80—94
1909					1873			

References

ÁGFALVI, R. (Hrg.) (1987): Iskola-egészségügyi kézikönyv (Schulhygienisches Handbuch). — Medicina Könyvkiadó. Budapest.

BALLAI, K. (1918): Adatok a magyar gyermek hosszúság-szélességi koponyajelzőjének ("kephal-indexé"-nek) megállapításához (Angaben zur Feststellung des Kephalindex des ungarischen Kindes). — A gyermek. *12*, 209—239.

BALLAI, K. (1923): A magyar gyermek testi kifejlődése. I. Matyó fiúk (Von der körperlichen Entwicklung der ungarischen Kinder. I. "Matyó"-Kinder). — Antrop. Füzetek. *1*, 36—43.

BALLAI, K. (1929): A magyar gyermek. Eredeti mérések és lélektani adatok alapján (Das ungarische Kind auf Grund Originalmessungen und psychologischer Beobachtungen). — Magyar Gyermek-tanulmányi Társaság. Budapest. 90 S.

BARTUCZ, L. (1938): A magyar ember. A magyarság antropológiája (Der Ungar. Antropologie des Ungartums). — Magyar föld magyar faj. 4. kötet. Egyetemi nyomda. Budapest. 299, 302.

BUDAY, J. (1978a): A fej antropometriai vizsgálata oligofrén gyermekeknél (Antropologische Untersuchung des Kopfes bei oligophrenischen Kinder). — Gyógyped. Szle. *6*, 241—248.

BUDAY, J. (1978b): Értelmi fogyatékos gyermekek fejméreteinek vizsgálata (Untersuchung der Kopfmasse bei geistig mindenwertigeren Kindern). — XIII. Biol. Vándorgyűlés. Budapest. 46—48.

DEZSŐ, GY. (1967): The changes of some cephalic measurements of school children aged 7—14 years in Budapest. — Ann. Hist.-nat. Mus. Nat. Hung. *59*, 485—491.

DOBÁNY, I. (1958): A fül morfológiai és méretbeli változásainak vizsgálata 7—18 éves gyermekeken (Untersuchungen über die morphologischen und metrischen Veränderungen des Ohres bei 7—18 jährigen Kinder). — Anthrop. Közl. *2*, 93—122.

EIBEN, O. (1967): Gyermekek fej- és arcméreteinek változása nyugatmagyarországi vizsgálatok alapján (Changes of head and face dimensions of children on the basis of West-Hungarian surveys). — Anthrop. Közl. *11*, 165—185.

EIBEN, O. and PANTÓ, E. (1984): A magyar gyermek cephal-indexe — hetven évvel később (The cephalic-index of the Hungarian child — Seventy years later). — Anthrop. Közl. *28*, 25—31.

FARKAS, GY. (1961): Szegedi 6—18 éves fiúk és lányok főbb testméretei (Wichtigere Körpermasse 6 bis 18-jähriger Knaben und Mädchen in der Stadt Szeged). — Anthroph. Közl. *4*, 103—135.

FARKAS, GY. (im Druck): A békéscsabai fiatalok testi fejlettsége (Körperliche Entwicklung der jungendlichen von Békéscsaba). — Békéscsaba Monográfiája.

HEGYI, I. und TÖRÖK, J. (1968): A külső koponyatérfogat mérés jelentősége csecsemőkorban (Über die Bedeutung der Bestimmung des äusseren Schädelvolumen in Säuglingsalter). — Gyermek-gyógyászat. *19*, 73—76.

KAROSSA-PFEIFFER, J. und MELLY, J. (Hrg.) (1959): Az iskolaorvos zsebkönyve (Handbuch des Schulartztes). — Medicina könyvkiadó. Budapest.

KÓCZIÁN, L. (1910): A tanuló ifjúság testtani vizsgálata (Somatologische Untersuchung der Schuljugend). — A máramarosszigeti kir. kat. gimn. Értesítője 1909—1910.

KONRÁDI, D. (1911): Schulärztliche Beobachtungen. —Internat. Arch. Schulhyg. *7*, 121—128.

LIPP, I. (1938): A sárréti magyarság anthropologiája (Anthropologie des Ungartums im Sárrét). — Bölcsészdoktori értekezés. Székesfehérvár. 45 S.

MALÁN, M. (1947): Az élő magyarság embertani kutatása (Anthropologische Forschungen des heutigen Ungartums). — In: GYÖRFFY GYÖRGY (Szerk.): A magyar népkutatás kézikönyve. Budapest. 36 S.

MARTIN, R. und SALLER, K. (1956): Lehrbuch der Antropologie. Bd. 1. Stuttgart. 323—343.

NEMESKÉRI, J. (1953): Ivád község népének embertani vizsgálata (Anthropologische Untersuchung der Population von Ivád, Ungarn). — MTA Biol. Oszt. Közl. *2*, 200—238.

NYILAS, K. (1980): A Rétköz általános iskolás korú tanulóinak néhány fejmérete egy keresztmetszeti vizsgálat alapján (Einige Kopfmasse der Kindern in der Grundschule von Rétköz (Ungarn) auf Grund der Querschnittuntersuchung). — Acta Acad. Pead. Nyiregyháziensis. *8/D*, 149—240.

NYILAS, K: (1982a): A rétközi általános iskolás korú tanulók fejméreteinek összehasonlító vizsgálata (Vergleichende Untersuchung der Kopfmasse der Kinder in der Grundschule von Rétköz, Ungarn). — Acta Acad. Paed. Nyiregyháziensis. *9/F*, 109—172.

NYILAS, K. (1982b): Egy földrajzi tájegység, a Rétköz 6—14 éves általános iskolai tanulóinak testi fejlettsége (Physical development of 6—14 year old pupils of public elementary schools in a geographical unit (the Rétköz). — Humanbiol. Budapest. *12*, 139—144.

NYILAS, K. (1983): A rétközi általános iskolai tanulók néhány testmérete (Einige Körpermasse der Grundschulkinder von Rétköz, Ungarn). — Nyíregyháza. Bessenyei György Tanárképző Főikola. 250 S.

NYILAS, K. (1983): A rétközi gyermekek relatív testméretei és indexei (Die relative Körpermasse und Indices der Kinder von Rétköz, Ungarn). — Nyíregyháza. Bessenyei György Tanárképző Főiskola. 125 S.

NYILAS, K. (1987): A rétközi gyermekek testi fejlettsége, biológiai státusa (Körperliche Entwicklung der Kinder von Rétköz und ihrer biologische Status). — Kandidátusi Értekezés. Nyíregyháza. 127 S.

NYILAS, K. und NYILAS, K. (1985): A vásárosnaményi óvodások antropológiai vizsgálata (Anthropologische Untersuchung der Kinder in den Kindergärten von Vásárosnamény, Ungarn). — Acta Acad. Paed. Nyíregyháziensis. *10/F*, 155—181.

PALIK, K. I. (1965): Négyezer iskolásgyermek psychosomatikus statusa (The psychosomatic status of 4000 schoolboys and girls). — Anthrop. Közl. *9*, 31—55.

RAJKAI, T. (1967): Általános iskolás gyermekek fejméreteinek változásai hosszmetszeti vizsgálatok alapján (Änderung der Kopfabmessungen von Grundschulenschülern auf Grund von Längsschnittuntersuchungen). — Anthrop. Közl. *11*, 5—24.

SZABÓ, T. (1982): A kisvárdai járás értelmi fogyatékos gyermekeinek antropológiai vizsgálata (Anthropologische Untersuchung der geistig mindenwertigeren Kindern von Distrikt Kisvárda, Ungarn). — Acta Acad. Paed. Nyíregyháziensis. *9/F*, 189—232.

SZÉNÁSY, J. (1968): Über den Zusammenhang zwischen dem pathologischen Kopfwachstum und dem Gewicht von Säuglingen. — Acta Ped. *9*, 133—137.

SZÉNÁSY, J. (1971): A csecsemő koponyanövekedésének és súlygyarapodásának összefüggéséről (Über den Zusammenhang zwischen Schädelwuchs und Gewichtszunahme des Säuglings). — Gyermekgyógyászat. *22*, 111—117.

SZILÁGYI, M. K. (1968): Értelmi fogyatékos gyermekek néhány fejmérete (Some head-measures of mentally deficient children). — Anthrop. Közl. *12*, 31—42.

SZILÁGYI, M. K. (1972): Anthropological examination on mentally defective children. In: TÖRŐ IMRE—SZABADY EGON—NEMESKÉRI JÁNOS—EIBEN OTTÓ (Eds.): Advances in the biology of human population. — Akadémiai Kiadó. Budapest. 413—420.

TÖRÖK, E. (1913): Koponya körfogat és szellemi fejlettség (Umfang des Schädels und gestige Entwicklung). — Klinikai Füzetek. 151—156.

TUSZKAI, Ö. (1911): Iskolaorvosi tapasztalatok (Schulärztliche Erfahrungen). — Budapesti Orvosi Ujság. *9*, 25—32.

VÁGÓ, I. (1965): Az orr méretbeli és morfológiai változásai 6—18 éves budapesti gyerekeken (Die dimensionalen und morphologischen Veränderungen der Nase bei Budapester Kindern von 6 bis 18 Jahren). — Anthrop. Közl. *9*, 77—78.

VÉGHELYI, P. (Hrg.) (1975): Gyermekgyógyászati vademecum (Kinderheilkundliches Vademekum). — Medicina könyvkiadó. Budapest. 534—548.

ACTA BIOL. SZEGED. 34. PP. 155—156 (1988)

SHORT COMMUNICATION

POSTEFFECT OF SULFATE STRESS AT VARYING NITROGEN SUPPLY ON THE K^+ UPTAKE AND GROWTH OF CUCUMBER SEEDLINGS

F. ZSOLDOS, E. HAUNOLD*, Á. VASHEGYI AND P. HERGER*

Department of Plant Physiology, Attila József University
H—6701 Szeged, P.O.B. 654. Hungary
**Institute of Agriculture, Austrian Research Centre Seibersdorf,*
A—2444 Seibersdorf, Austria.

(Received: October 10, 1988)

Earlier it was demonstrated by us that roots pretreated with high levels of NO_3^- absorbed more K^+ than seedlings treated with low levels of NO_3^- which indicates a definite regulation of the K^+ uptake by continuous NO_3^- supply of seedlings (ZSOLDOS et al., 1984, 1986). Our data indicated that under NO_3^- deficiency condition a definite inhibitory posteffect of internal K^+ on the K^+ influx of roots could occur. This assumption was supported by the K^+ internal concentration of the roots too.

Recently we found the same posteffect in the K^+ influx of roots when seedlings grown under S-deficient, or suboptimal S-supply conditons (Fig. 1). The question arises, how can this effect be explained? Our results suggest that when plants are sulfate deficient, an allosteric regulation of K^+ uptake could occur (ZSOLDOS et al., 1988). Namely, it is known from the literature that under S-deficient condition the nitrate reductase activity decreases (FRIEDRICH and SCHRADER, 1978) and therefore the inside NO_3^- concentration of roots increases, which causes a high K^+ influx into the roots.

As regards the growth and dry matter yield of seedlings it was found that NO_3^- utilization is definitely influenced by the sulfate supply of plants. Under our experimental conditions the maximum shoot growth can be experienced at 10 mM NO_3^- concentration and 0.1 mM SO_4^{2-} treatment. At the same time the effect on root growth (elongation) is quite different. Namely, under S-deficient conditions, like in the case of N deficiency, root system grows rapidly in length, but with reduced branching. The reason of which, however, at pressent is unknown.

Summing up, from our data it seems that the K^+ uptake (influx) anomaly in plants under S-deficient condition is induced by NO_3^- accumulation in roots. Sulfate deficiencies influence both root and shoot growth, but appreciable differences may be experienced between them. As far as practical agriculture is concerned, our conclusion is: the higher the N concentration in the root zone the more important the optimal S-supply for plants. An unsufficient supply of SO_4^{2-} can unfavourably affect both the yield and quality of crop (STEWART and PORTER, 1969).

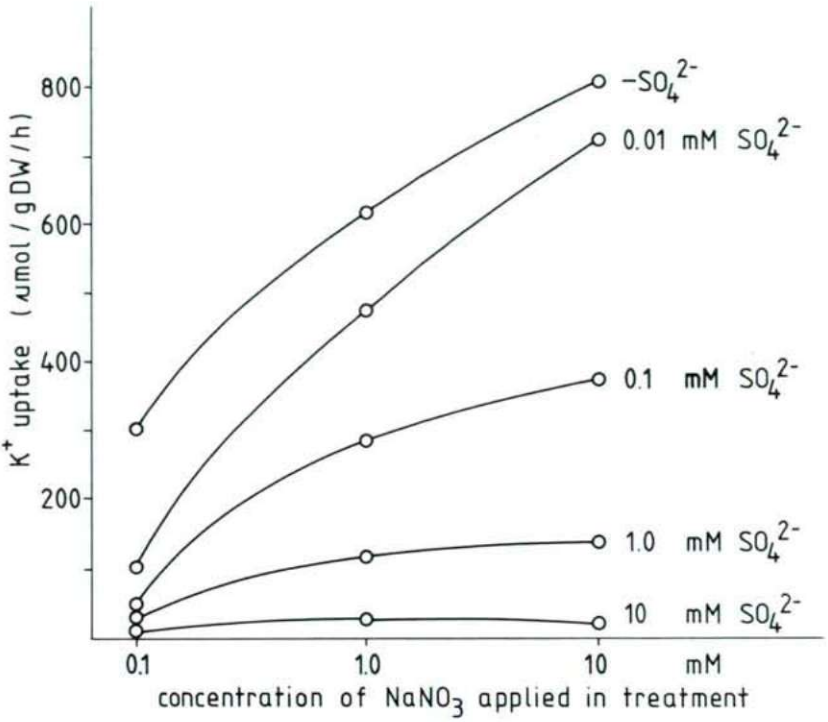


Fig. 1. Posteffect of increasing sodium sulfate supply at three NO_3^- levels on K^+ uptake of 7-day-old cucumber seedlings grown in modified Hoagland solution. Uptake solution: 1 mM K(^{86}Rb)Cl + 0.5 mM $CaCl_2$.

Acknowledgements

The work was carried out under the Austro—Hungarian Scientific and Technical Agreement. Project No. 10100 and 4.2., respectively.

References

FRIEDRICH, J. W. and SCHRADER, L. E. (1978): Sulfur deprivation and nitrogen metabolism in maize seedlings. — Plant Physiol. 61, 900—903.

STEWART, B. A. and PORTER, L. K. (1969): Nitrogen-sulfur relationship in wheat (Triticum aestivum L.), corn (Zea mays) and beans (Phaseolus vulgaris). — Agron. J. 61, 267—271.

ZSOLDOS, F., SÁGI, F., VASHEGYI, Á. and LOMNICZI, H. (1984): Nutrient deficiency and its effects on ion uptake, transpiration and dry-matter production by wheat. — Proc. VIth Intern. Congr. on Soilless Culture, Lunteren, pp. 801—808.

ZSOLDOS, F., HAUNOLD, E. and VASHEGYI, Á. (1986): Effects of nitrogen supply on potassium uptake and content of roots. — 5th FESPP Congress, Hamburg, 5, 42.

ZSOLDOS, F., HAUNOLD, E., VASHEGYI, Á. and HERGER, P. (1988): Potassium and sulfate uptake of wheat and cucumber roots stressed with nitrogen and sulfate salts. — Book of Abstracts, XIXth ESNA Ann. Meeting, Vienna, p. 212.

ACTA BIOL. SZEGED. 34. PP. 157—159 (1988)

SHORT COMMUNICATION

ABOUT THE SYMMETRY OF THE PENTAGONAL BASIC BIOPOLYMER UNITS OF THE POLLEN WALL

M. KEDVES

Department of Botany, Attila József University, H—6701 Szeged, P.O. B. 657, Hungary

(Received: June 22, 1988)

By direct and indirect methods, several concepts were published about the biopolymer structure and organization of the sporoderm, e.g.: Globular units (KEDVES et al. 1974), helical sub-units (ROWLEY et al. 1980, 1981). Irregular polygons forming a lattice pattern were described by SOUTHWORTH (1985, 1986). The pseudo-crystalline organization of the sporoderm was presumed by ROWLEY and SOUTHWORTH (1967). The molecular sieve character of the sporoderm was established by ROWLEY (1973). In our investigations pentagonal polygon units of the spore-pollen wall were observed. A regular, quasi-crystalline organization was supposed in the latest paper by the author (KEDVES, 1988a,b). Following the advice of Prof. Dr. J. KOVÁCS (Dept. of Zoology, E.L. University, Budapest), the Markham rotation method was used in the study of the symmetry of the pentagonal biopolymer units of the exine of *Pinus griffithii* MC.CLELL As a first attempt the photo paper was turned five times by 72° for the angles of the pentagonal polygon. The result (Fig. 4) was very surprising and on the other hand gave new verification to the quasi crystalline basic biopolymer structure of the sporoderm. The detailed description and the perspectives and further result in this field are the subject of another paper.

Plate 1.

Pinus griffithii MC.CLELL partially degraded exine of the pollen grain (experiment, No 79: 20 mg air dried pollen grains + 1 ml 2-aminoethanol, temperature 30°C, lenght of time 24^h + 10 ml KMnO4 aq. dil., temperature 30°C, lenght of time 24^h. Fig. 1—3 — TEM pictures without rotation; 1. x200000, 2.x500000. 3.x1250000. Fig. 4. TEM picture prepared with the Markham rotation method; five times, x1250000.

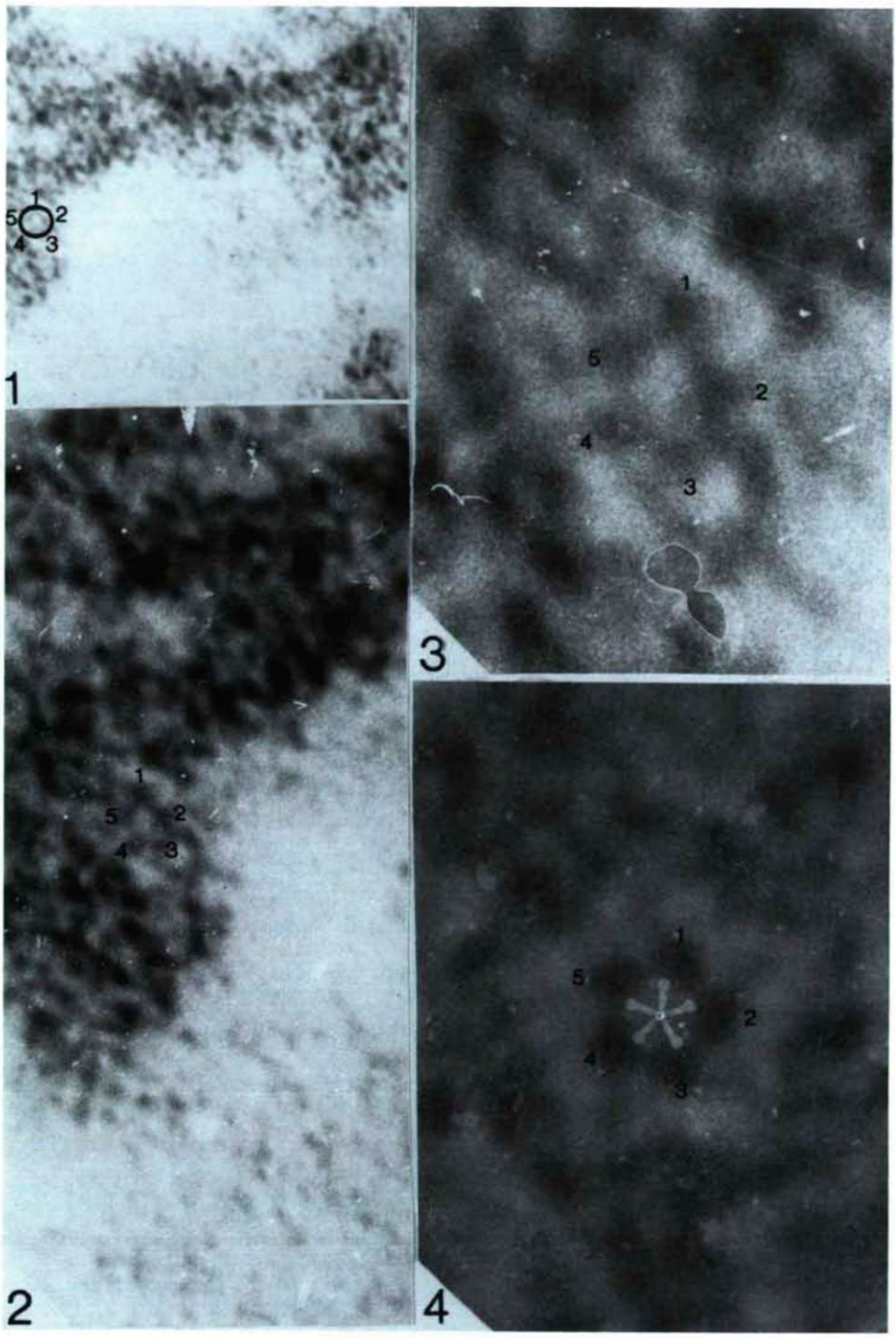
References

KEDVES, M. (1988a): Quasi-crystalloid basic molecular structure of the sporoderm. — 7 Int. Palynol. Congr. Abstr., in print.

KEDVES, M. (1988b): First observations on the higher organized biopolymer structures of the exine of bisaccate gymnosperm pollen grains. — Acta Biol. Szeged *34*, in print.

KEDVES, M., STANLEY, E.A. and ROJIK, I. (1974): Observations nouvelles sur l'ectexine des pollens fossiles des Angiospermes de l'Eocène inférieur. — Pollen et Spores *16*, 425—437.

ROWLEY, J.R. (1973): Translocation through the pollen wall. — J. Ultrastructure Res. *44*, 449—450.


1
5
2
4
3
1
2
3
5
1
2
3
4
5
1
2
3
4
5

ROWLEY, J.R. and SOUTHWORTH, D. (1967): Deposition of sporopollenin on lamellae of unit membrane dimension. — Nature *213*, 703—704.

ROWLEY, J.R., DAHL, A.O., and ROWLEY, J.S. (1980): Coiled construction of exinous units in pollen *Artemisia*. — 38th Ann. Proc. E.M. Soc. Amer., 252, 253.

ROWLEY, J.R., DAHL, A.O., SENGUPTA, S. and ROWLEY, J.S. (1981): A model of exine substructure based on dissection of pollen and spore exines. — Palynology *5*, 107—152.

SOUTHWORTH, D. (1985): Pollen exine substructure. I. *Lilium longiflorum*. — Amer. J. Bot. *72*, 1274—1283.

SOUTHWORTH, D. (1986): Substructural organization of pollen exines. — Pollen and Spores: Form and Function, 61—69.

ACTA BIOL. SZEGED. 34. PP. 161—163 (1988)

SHORT COMMUNICATION

FIRST OBSERVATION ON THE HIGHER ORGANIZED BIOPOLYMER STRUCTURES OF THE EXINE OF BISACCATE GYMNOSPERM POLLEN GRAINS

M. KEDVES

Department of Botany, Attila József University, H—6701 Szeged, P.O. B. 657, Hungary

(Received: August 14, 1987)

During our experimental studies of the biopolymer structures of the sporoderm of recent and fossil taxa, with the Helix enzyme method we have established differences between the gymnosperm and angiosperm exines (KEDVES, 1987a). But SOUTHWORTH (1985a,b, 1986) using the acetolysis method and the partial extraction with hot 2-aminoethanol described the granular substructures of the exines which are arranged in pentagonal polygons at the pollen grains of recent *Lilium longiflorum* THUNB., *Fagus sylvatica* L., and *Juniperus communis* L. Our new experiment on the degradation partial of the exines by different solvents, combined with the TEM method, resulted some new information about the biopolymer organization of the spore-pollen wall. Among others, the method with 2-aminoethanol, and $KMnO_4$ aq. dil. resulted in the pentagonal polygon subunits at several taxa, including gymnosperm and angiosperm pollen grains, too (KEDVES, 1987b). In this way, by the different methods different results were achieved on the same subject. Since during our first experimental studies, the saccate gymnosperm pollen grains seemed to be the most difficult in this respect, studies of the pollen grains of the genera *Pinus* and *Abies* were carried out. This paper as a preliminary report summarizes the first results on the partially degraded exine of *Abies concolor* HOOPES: 1. The pentagonal polygon subunits, as the quasi crystalline structure was observed at the whole part of the exine of the pollen grain. 2. On the surface there are larger (25—37 Å) globular units (cf. KEDVES et al., 1974, HESSE, 1985). 3. Remnants of lamellar structure were observed at the foot layer. This must be studied later, but the lamellar foot layer, based on our up-to-date knowledge exhibits an early ultrastructural characteristic feature. A characteristic lamellar foot layer was described by MEYER and RASKATOVA (1984) from the most earlier saccate gymnosperm pollen grain (*Archaeoperisaccus* NAUM.). MILLAY and TAYLOR (1974) described lamellar layer from Paleozoic saccate gymnosperm pollen grains; *Felixipollenites, Vesicaspora*. In this respect it is important that foot layer of the *Triadispora bölchii* SCHEURING 1970 from the Triassic is compact (SCHEURING, 1976). Following VAN CAMPO and SIVAK (1972) on fractured exine of the recent *Abies concolor*, on the SEM pictures seems to be compact. The detailed study of the biopolymer organization on the recent saccate gymnosperm pollen grains will be published later.

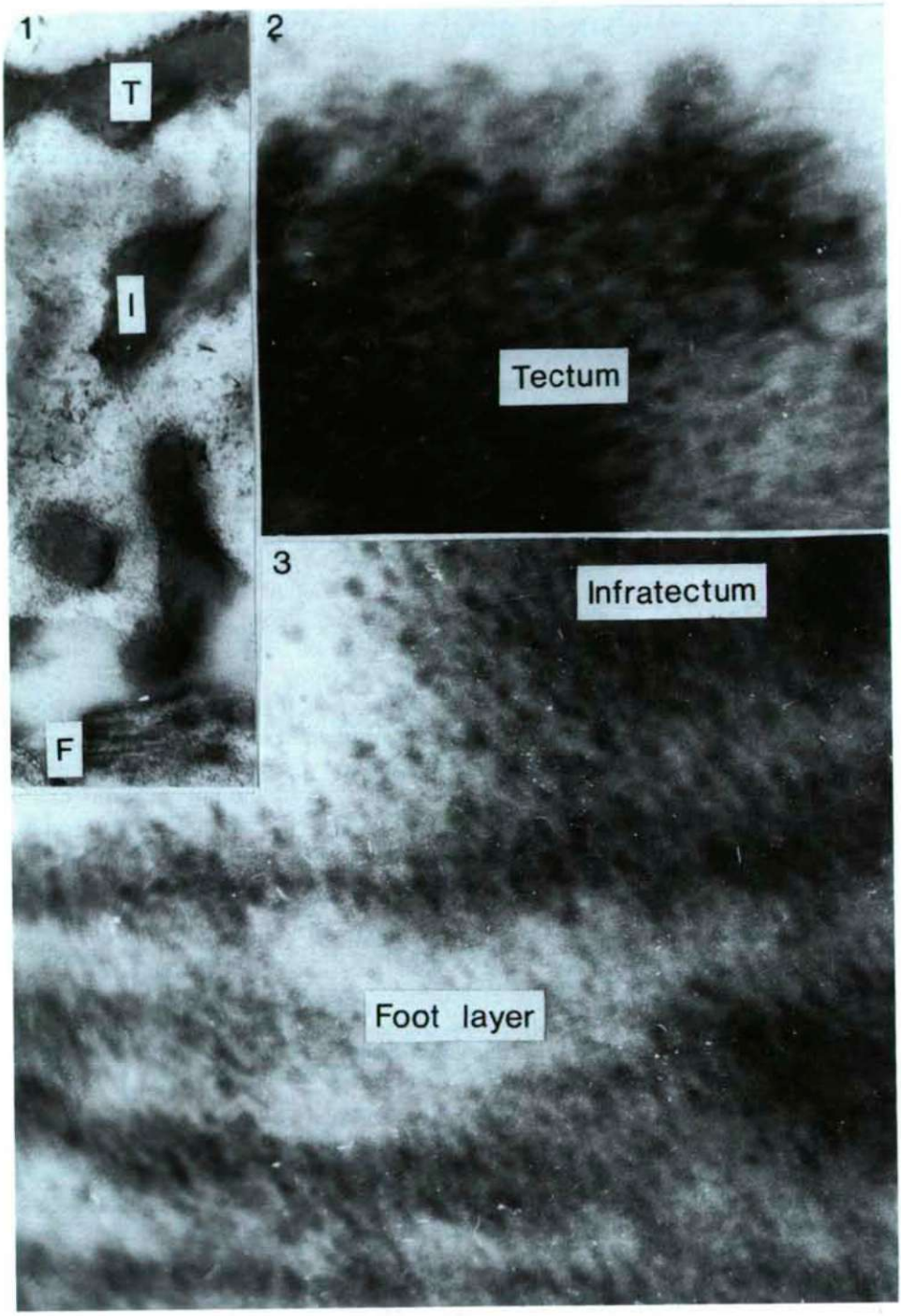

1
T
I
F
2
Tectum
3
Infratectum
Foot layer

Plate 1.

Abies concolor HOOPES, partially degraded exine of the pollen grain (Experiment, No 81: 20 mg air dried pollen grains — 1 ml 2-aminoethanol, temperature 30°C, lenght 24 + 10 ml KMnO4 aq. dil., temperature 30°C, lenght of 24^{h}. 1. x50000, 2,3,.x500000.

References

HESSE, M. (1985): Hemispheric surface processes of exine and orbicules in *Calluna (Ericaceae)*. — Grana *24*, 93—98.

KEDVES, M. (1987a): Degradation of the sporoderm under natural and in vitro conditions. — XIV Int. Bot. congr., Abstr., 295.

KEDVES, M. (1987b): Higher organized sporopollenin biopolymer structures and the explosion of the pollen grains under scanning effect. — Acta Biol. Szeged *33*, 163—165.

KEDVES, M., STANLEY, E.A. and ROJIK, I. (1974): Observations nouvelles sur l'ectexine des pollens fossiles des Angiospermes de l'Éocène inférieur. — Pollen et Spores *16*, 425—437.

MEYER, N.R. and RASKATOVA, L.G. (1984): Exine structure of *Archaeoperisaccus* NAUM. (the results of electronmicroscope investigation on pollen grain section). — Problems of Modern Palynology, 91—95 (In Russian).

MILLAY, M.A. and TAYLOR, T.N. (1974): Morphological studies of Paleozoic saccate pollen. — Palaeontographica B, *147*, 75—99.

SCHEURING, B.W. (1976): Proximal exine filaments, a widespread feature among Triassic *Protosaccites* and *Circumpolles* to secure the dispersal of entire tetrads. — Pollen et Spores *18*, 611—639.

SOUTHWORTH, D. (1985a): Pollen exine substructure. I. *Lilium longiflorum*. — Amer. J. Bot. *72*, 1274—1283.

SOUTHWORTH, D. (1985b): Pollen exine substructure II. *Fagus sylvatica*. Grana *24*, 161—166.

SOUTHWORTH, D. (1986): Pollen exine substructure III. *Juniperus communis*. — Can. J. Bot. *64*, 983—987.

VAN CAMPO, M. and SIVAK, J. (1972): Structure alvéolaire de l'exine des pollens à ballonnets des Abietacées. — Pollen et Spores *14*, 115—141.

ACTA BIOL. SZEGED. 34. PP. 165 (1988)

SHORT COMMUNICATION

NEW HABITAT OF STERNBERGIA COLCHICIFLORA W. ET K. 1803 IN HUNGARY

P. PAULOVICS, ZS. MOLNÁR AND L. KÖRMÖCZI

Department of Botany, Attila József University
H—6701 Szeged, P.O.B. 657. Hungary

(Received: October 5, 1988)

On 1st of May 1988 PÉTER PAULOVICS and ZSOLT MOLNÁR discovered about 40 *Sternbergia colchiciflora* individuals of fruiting state in the eastern region of Csongrád county, 3 km southwest from Csanádalberti, at the souther part of Pitvarosi puszta, that is referred to as Blaskovics puszta.

In the course of study of literature it became evident that the occurrence of this plant at the southeastern part of Great Hungarian Plain is known only at the region of Csorvás (SOÓ, 1973; CSAPODI, 1982). From the last century several data can be found on the presence of *Sternbergia* at pusztas of Békés county (PAWLOWSKY, cit. in BORBÁS, 1881).

During a thorough walking all over the puszta we found several new colonies. In the time of flowering peak (21—25. 09.) we counted the flowers, and nearly 6500 individuals were counted at the Blaskovics puszta and at a northern part, Montág puszta together (about 1 km far from the previous one).

Plants formed 3 larger (700, 2300, 2500 individuals, respectively) and several smaller groups in some km distance from each other. The larger groups occupied about 2—5 ha areas.

This plant grows here in *Achilleo-Festucetum pseudovinae* SOÓ 33 association, characteristic species of which are as follows: *Achillea collina, Festuca pseudovina, Adonis vernalis, Phlomis tuberosa, Thalictrum minus, Fragaria viridis, Filipendula vulgaris, Salvia austriaca, Salvia memorosa, Verbascum phoeniceum, Ajuga genevensis.*

References

BORBÁS, V. (1881): Békésvármegye flórája. (Flora of Békés county. In Hungarian.) — Akadémiai Könyvkiadó, Budapest.

CSAPODY, I. (1982): Védett növényeink. (Protected plants. In Hungarian). — Gondolat Könyvkiadó, Budapest.

SOÓ, R. (1973): A magyar flóra és vegetáció rendszertani-növényföldrajzi kézikönyve V. (Systematic-phytogeographic handbook of Hungarian flora V. In Hungarian). — Akadémiai Kiadó, Budapest.

ACTA BIOL. SZEGED. 34. PP. 167—168 (1988)

SHORT COMMUNICATION

A CHECK LIST OF ANTS (HYMENOPTERA: FORMICOIDEA) OF A SANDY GRASSLAND IN KISKUNSÁG NATIONAL PARK (HUNGARY)

L. GALLÉ AND G. SZŐNYI

Department of Zoology, Attila József University
H—6701 Szeged, P.O.B. 659, Hungary

(Received: June 22, 1988)

Abstract

The check list of a sandy grassland plot of 2.5 ha contains 30 ant species, about one third of whole Hungarian *Formincoidea* fauna. Some new (*Myrmica schencki, Epimyrma goesswaldi, Tapinoma ambiguum, Lasius carniolicus*) and rare (*Plagiolepis xene, Anergates atratulus*) species have been found for the Hungarian fauna. The high diversity is explained by the heteromorph environmental character, presence of transitional successional stages and the high immigration rate.
Key words: Formicoidea, sandy grassland, Kiskunság National Park

Although a comprehensive identification key (SOMFAI, 1959) as well as some papers concerning local ant faunas of Bakony Mts. (GALLÉ, 1978) and national parks (GALLÉ, 1981, 1986 and in press) have been published, the Hungarian ant fauna is not sufficiently studied. From careful and detailed studies we can expect species being known as new or rare in Hungary. An enumeration of ant species living in the Kiskunság National Park is given by GALLÉ (1986), but since then several additional species have been collected in the research area.

The ant material, present short paper is based upon, was collected in a 2.5 ha research plot of a sandy grassland in Kiskunság National Park in the period from 1976 to 1987. Most ants were cought by Barber traps. Altogether 70—90 traps were continuously used from March to November in each of eleven years (1977—1987). In addition, hand collections, tray traps, window traps and sweep nets provided a considerable amount of ants, too.

The list of species is as follows:

Familia *Myrmicidae*
Myrmica rugulosa NYLANDER, 1849
Myrmica sabuleti MEINERT, 1860
Myrmica schencki EMERY, 1896
Diplorhoptrum fugax (LATREILLE, 1798)
Anergates atratulus (SCHENCK, 1852)
Leptothorax interruptus (SCHENCK, 1852)
Leptothorax nylanderi (FOERSTER, 1850)
Epimyrma goesswaldi MENOZZI, 1931
Tetramorium caespitum (LINNAEUS, 1758)
Tetramorium impurum (FOERSTER, 1850)?

Familia: *Dolichoderidae*
Dolichoderus quadripunctatus (LINNAEUS, 1758)
Tapinoma ambiguum EMERY, 1925

Familia: *Formicidae*
Plagiolepis vindobonensis LOMNICKI, 1925
Plagiolepis xene STARCKE, 1936
Camponotus vagus (SCOPOLI, 1763)
Camponotus fallax (NYLANDER, 1850)
Lasius fuliginosus (LATREILLE, 1798)
Lasius niger (LINNAEUS, 1758)
Lasius alienus (FOERSTER, 1850)
Lasius flavus (FABRICIUS, 1781)
Lasius carniolicus MAYR, 1861
Lasius mixtus (NYLANDER, 1876)
Cataglyphis aenescens (NYLANDER, 1849)
Formica fusca LINNAEUS, 1758
Formica rufibarbis FABRICIUS, 1793
Formica cunicularia LATREILLE, 1798
Formica truncorum FABRICIUS, 1904
Formica pratensis RETZIUS, 1783
Formica sanguinea LATREILLE, 1798
Polyergus rufescens (LATREILLE, 1798)

This list contains the elements of four ant species assemblages living in different types of patches or habitats and this fact explains the high species number: (1) The ants of sand dunes are thermophilous and xerotolerant species such as *Lasius alienus, Plagiolepis vindobonensis, Formica cunicularia, Cataglyphis aenescens* etc. (2) The ant species living in wind grooves with higher and denser vegetation are e.g. *Lasius niger, Formica rufibarbis, F. sanguineaa, Myrmica schencki, Myrmica sabuleti.* (3) Typical ants of transitional areas are *Tetramorium caespitum* and *Tapinoma ambiguum* with the parasite of *Tetramorium* species, *Anergates atratulus.* (4) The last group of species consists of immigrants from the sorrounding poplar and pine forests and forest edges, e.g. *Myrmica rugulosa, Leptothorax* spp., *Dolichoderus quadripunctatus, Camponotus* spp., *Formica pratensis, F. truncorum* etc. The immigration of the species belonging to this group ensures the continuation of ant community succession.

References

GALLÉ, L. (1978): Adatok a Bakony-hegység hangya (*Hymenoptera: Formicoidea*) faunájának ismeretéhez (Data to the knowledge of the ant fauna of Bakony Mts.). — Veszprém Megyei Múzeumok Közl., *14*, 234—244.

GALLÉ, L. (1981): The Formicoid fauna of Hortobágy, in: MAHUNKA, S. (ed.): The Fauna of Hortobágy National Park, Akad. Kiadó, Budapest, 307—311.

GALLÉ, L. (1986): The ant fauna of Kiskunság National Park, in: MAHUNKA, S. (ed.): The Fauna of Kiskunság National Park I., Akad. Kiadó, Budapest, 427—434.

SOMFAI, E. (1959): Formicoidea — Hangya alkatúak, in: SZÉKESSY, V. (ed.): Fauna Hungariae, 12, 4, Akad. Kiadó, Budapest, 1—79.

ACTA BIOL. SZEGED. 34. PP. 169—171 (1988)

SHORT COMMUNICATION

PRELIMINARY DATA TO THE CLUTCH-SIZE OF TRACHELIPUS NODULOSUS C. L. KOCH IN DIFFERENT HABITATS

E. HORNUNG

Department of Zoology, Attila József University
H—6701 Szeged, P.O.B. 659, Hungary

(Received: January 20, 1988)

Isopods are known as being mainly interoparous animals, reproducing more times during their relatively short life-span (up to 5 years). The number of eggs/offsprings produced by different isopod species has been stated very often by several authors. It is a fact that the number of eggs/embryos can change between wide ranges not only in the case of different species but at the same species, too. Instead of a long list of data and authors see the latest and — up to this time — the most detailed review on "breeding pattern in isopods" by WARBURG (1987). He summerises 128 data of 51 authors for 62 species.

It is also generally known and accepted that the number of eggs per female within a population is in close linear correlation with the size of pregnant females (summerized by WARBURG et al., 1984). The problem of the above mentioned differences in clutch-size in the case of one species is a remarkable problem in connection with isopods' life-history strategies. The great geographical distances, different latitudes can be one of the main reasons because of their macrosynaptical characteristics (light intensity, day length, temperature, etc.) as it was stated by JUCHAULT et al. (1980) on *Armadillidium vulgare* LATR. But habitat parameters (microclimate, vegetation, shelter sites, etc.) may have the same importance, as well.

I have studied three populations of *T. nodulosus* at three altering habitats during nearly the same time period. All the three localities can be found in South-East Hungary, on the Great Plain, not in far geographic distances that is under the same macroclimatic conditions.

The habitats and their main characteristics:

1. Bugac — Kiskunság National Park (80 km NW from Szeged). It is a pasture, an open grassland with wind blown sandy soil, low soil moisture content (for detailed data see BODROGKÖZY and FARKAS, 1981; KÖRMÖCZI at al., 1981).

2. Ásotthalom — Emlékerdő (30 km from Szeged). The area has nearly the same abiotic conditions and plant associations (BODROGKÖZY, 1957) as Bugac, with a great difference: there are poplar patches with logs and a thin litter layer where isopods can aggregate and find hiding places.

3. Szeged — Szőreg (7 km from the city-centrum) can be characterised by a *Lolio-Plantaginaetum* plant association. Its soil is dense with a high moisture content in spring and early summer. There are a lot of stones, brick pieces wich retain humidity and prove to be excellent shelters for cryptozoic animals.

The studied isopod species has two reproductive peaks in one breeding season (HORNUNG, 1984; in press). Its first breeding maximum was experienced in early June. The field observations were done during this period. All specimens found were caught, sexed, body length measured, and eggs/embryos counted. The data of the three investigated populations *(Table I.)* suggest that there are expressed differences in average egg number and body length of pregnant females even at this widespread, relatively modest species.

Table I. Data of pregnant females in different habitats (June, 1987) (Minimum-maximum values in brackets)

Habitat	Average body length (mm)	Average egg number in marsupium	Sex rate	Fecundity rate
Bugac	9.66	25.78 (14—40)	0.63	0.3
Ásotthalom	12.1	38.71 (25—75)	0.5	0.46
Szőreg	13.68	55.64 (15—106)	0.68	0.86

The investigated habitats can be arrenged on a gradient from most favourable (Szőreg) to most unfavourable (Bugac) based on their environmental factors. The data of the three populations *(Table I.)* seem to be in close connection with habitat characteristics. The environmental conditions influence the size of specimens, clutch-size of females and also the survivorship, so the maintanance, spread limits of a population.

The raised question seems to be worth for further investigations, stating of effective environmental factors, needs more research at a series of various habitats and at different species as well.

References

BODROGKÖZY, GY. (1957): Die Vegetation der weispappel-Haine in dem Reservat 'Emlékerdő' bei Szeged-Ásotthalom. — Acta Biol. Szeged. *3*, 127—140.

BODROGKÖZY, GY. and FARKAS, GY. (1981): Correlation between vegetation and hydroecology in the sandy grassland of Kiskunság National Park. — Acta Biol. Szeged. *27*, 33—53.

HORNUNG, E. (1984): Characteristics of the population of an isopod species (*Trachelipos nodulosus* C.L. KOCH) at a sandy soil grassland. — Acta Biol. Szeged. *30*, 153—158.

HORNUNG, E. (in press): Population dynamics and spatial distribution of *Tranchelipus nodulosus* C.L. KOCH in a sandy grassland. — Mon. Zool. It.

JUCHAULT, P., PAVESE, A. and MOCQUARD, J.P. (1980): Déterminisme de la reproduction saisonniére des femelles d'*Armadillidium vulgare* LATR. (Crustacé, Isopode, Oniscoide), II Étude en conditions expérimentales des femelles d'origines géographiques différentes. — Ann. Sci. Nat. (Zool.), *2*, 99—108.

KÖRMÖCZI, L., BODROGKÖZY, GY. and HORVÁTH, I. (1981): Investigation of biological production and bioclimate of sandy grassland in Bugac (Great Hungarian Plain between Danube and Tisza). — Acta Biol. Szeged. *27*, 55—69.

WARBURG, M.R., LINSENMAIR, K.E. and BERCOVITZ, K. (1984):The Effect of Climate on the Distribution and Abundance of Isopods. — Symp. Zool. Soc., Lond. *53*, 339—367.

WARBURG, M.R. (1987): Isopods and Their Terrestrial Environment. — Advances in Ecological Research *17*, 187—242.

ACTA BIOL. SZEGED. 34. PP. 173—176 (1988)

SHORT COMMUNICATION

AGE DETERMINATION OF MEGAPHYLLUM UNILINEATUM (C.L.KOCH) (DIPLOPODA: JULIDAE)

E. HORNUNG AND Z. VAJDA

Department of Zoology, Attila József University
H—6701 Szeged, P.O.B. 659, Hungary

(Received: January 20, 1988)

Knowledge of age groups, separation of developmental stages is a basic problem of population studies. A good method can be expecially important at populations which have overlapping generations. We met this problem at studying the population dynamics of *Megaphyllum unilineatum* (C.L. KOCH) (HORNUNG and VAJDA, 1987). This species is an interoparous one, surviving after laying her first brood and reproduces more times during its life-span (up to 5 years; SCHUBART, 1934). Adults are always present in the population. Eight development stages -seven larval and an adult- can be distinguished in the species (VACHON, 1947).

M. unilineatum is mentioned in taxonomical (SCHUBART, 1934; VERHOEFF, 1910—14; STOJALOWSKA, 1961) and some faunistical, general ecological studies (HAACKER, 1968; DUNGER and STEINMETZGER, 1981) but no population study is known for us on this species, wide-spread in Hungary.

Different authors used more kinds of methods for age determination at diplopods such as counting body segments, defensive glands, leg pairs, rows of ocelli, measuring body length, body weight, mid-segment width (see *Table I.*) We tested some of them but they showed — with the exception of rows of ocelli — large overlaps (*Table II.*), expecially in stages VI—VIII. and didn't give unambigous limits for determination of single stages. We found counting the number of ocelli to be the best method in the studied species.

Specimens of *M. unilineatum* were collected at Bugac, in the frame of the complex ecological studies of the ecological group of Zoological Department of JATE University. The material of seventy pit-fall traps (working from April till December) of 1983—85 was evaluated. Animals were stored in 70% alcohol. Ocelli of every single specimen (5961 individuals during the three years) were counted under dissecting microscope. Its result is shown by Fig. 1. On the basis of the present study the larval stages (I.—VII.) can be separated unambiguosly. There is no or not significant overlap in the number of ocelli. At the VIII. stage five maxima (Fig 1.: A1—A5) were found wich can be presumably corresponded to the age of adults. The life-span of *M. unilineatum* is estimated for 3—5 years (SCHUBART, 1934). As *M. unilineatum* is able to develop to the VIIIth stage within one year, the five maxima refers to the five years of adult stages. The decreasing frequency in individual numbers from A2 to A5 seems to present the natural tendency of decreasing adult number because of increasing age, that is the adult mortality.

Table I. Methods for age determination used by different authors.

	No. of segments	No. of legs	No. of def. glands	Rows of ocelli	Body length	Mid-segment width	Body weight
BAKER (1978b)	x			x			
BANO and KRISHNAMOORTHY (1985)	x	x			x		
BERCOVITZ and WARBURG (1985)					x	x	x
BLOWER (1985)				x			
HALKKA (1958)	x	x	x		x		
MEYER (1985)				x			
PEITSALMI (1981)			x				
SAUDRAY (1952)				x			
STRIGANOVA and MAZANTSEVA (1979)				x			x
PEITSALMI (1981)			x				

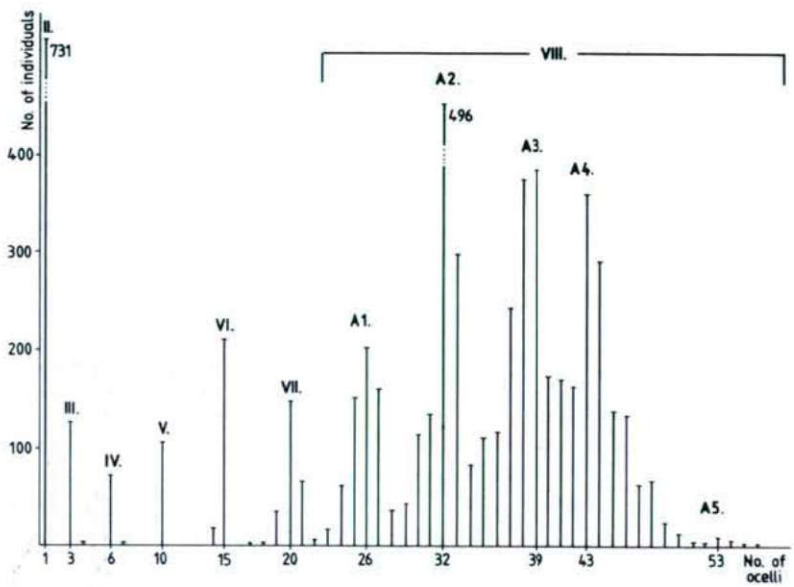


Fig. 1. Developmental stages in function of ocellus number

Table II. Results of the different methods for age determination of *Megaphyllum unilineatum* from II. to adult (VIII.) stage

Developmental stage	No. of segments average ± SD	Mid-segment width (mm) average ± SD		Peaks of ocellus number
II.	12.71 ± 1.36 (12—14)	*		1
III.	17.07 ± 0.65 (16—18)	*		3 (3—4)
IV.	21	0.56 ± 0.05 (0.48—0.65)	**	6 (5—7)
		males	females	
V.	28 ± 0.72 (27—29)	0.67 ± 0.06 (0.6—0.71)	0.69 ± 0.0 (0.62—0.88)	10
VI.	33.84 ± 1.11 (31—36)	0.83 ± 0.06 (0.72—0.92)	0.88 ± 0.08 (0.7—1.01)	15 (14—15)
VII.	38.01 ± 1.52 (32—44)	0.97 ± 0.08 (0.81—1.09)	1.07 ± 0.22 (0.9—1.46)	20 (17—22)
VIII.	43.59 ± 1.3 (42—48)	1.58 + 0.17 (1.08—2.23)	1.99 ± 0.36 (1.1—2.7)	age group 1. 26 2. 32 3. 39 4. 43 5. 53

Remarks: * — mid segment width cannot be measured;
** — sex cannot be distinguished;
minimum-maximum values in brackets

With this method we could separate developmental stages correctly. It became possibly to follow the changes of age groups within the population that is to make the population's temporal dynamics.

References

BAKER, G.H. (1978b): The post-embryonic development and life history of the millipede, *Ommatoiulus moreletii* (*Diplopoda: Iulidae*), introduced in southeastern Australia. — J.Zool.(Lond.) *186*, 209—228.

BANO, K. and KRISHNAMOORTHY, R.V. (1985): Reproductive Strategy and Life History of *Jonespeltis splendidus* (VERHOEFF) (*Diplopoda: Polydesmida*) with Environmental Synchronisation. — J.Soil.Biol.Ecol., *5(1)*, 48—57.

BERCOVITZ, K. and WARBURG, M.R. (1985): Developmental patterns in two populations of the millipede *Archispirostreptus syriacus* (DE SAUSSURE) in Israel (*Diplopoda*).—Bijdragen tot de Dierkunde, *55(1)*, 37—46.

BLOWER, J.G. (1985): Millipedes.—E.J. Brill/Dr. W. Backhuyss, London—Leiden—Köln—Kopenhavn.

DUNGER, W. and STEINMETZGER, K. (1981): Ecological Investigations on *Diplopoda* of a Grassland—Wood—Catena in a limestone Area in Thuringia (GDR). — Zool.Jb.Syst. *108*, 519—553.

HAACKER, U. (1968): Descriptive, experimentelle und vergleichende Untersuchungen zur Autökologie rheinmainischer *Diplopoden*. — Oecologia (Berl.), *1*, 87—129.

HALKKA, R. (1958): Life history of *Schizophyllum sabulosum* (L.) (*Diplopoda,Iulidae*). — Ann.Zool. Soc."Vanamo", *19(4)*, 1—72.

HORNUNG, E. and VAJDA, Z. (1987): Temporal and spatial distribution of a diplopod population (*Megaphyllum unilineatum* (C.L.KOCH)) in a sandy grassland. — Manuscript

MEYER, E. (1985): Distribution, activity, life-history and standing crop of *Julidae (Diplopoda, Myriapoda)* in the Central High Alps (Tyrol, Austria). — Holarctic Ecology, *8*, 141—150.

PEITSALMI, M. (1981): Population structure and seasonal changes in activity of *Proteroiulus fuscus* (Am Stein) (*Diplopoda, Blaniulidae*). — Acta Zool. Fenn., *161*, 1—66.

SAUDRAY, Y. (1952): Dévelopment post-embryonnaire d'un Iulide indigéne *Cylindroiulus (Aneuloboiulus) silvarum* MEINERT. — Arch. Zool. Exp. Gen., *89*, 1—14.

SCHUBART, O. (1934): Die Tierwelt Deutschlands, 28. Teil: Tausendfüssler oder Myriapoda I.: *Diplopoda*. — Gustav Fischer Verlag, Jena.

STOJALOWSKA, W. (1969): Krocionogi (*Diplopoda*) — Polski Panstwowe Wydawnictwo Naukowe, Warsawa.

STRIGANOVA, B.R. and MAZANTSEVA, G.P. (1979): Age and size structure of a population of *Pachyiulus foetidissimus (Diplopoda)* in the Caucasus. — Oikos, *32*, 416—421.

VERHOEFF, K.W. (1910—14): Die Diplopoden Deutschlands. — C.F. Winter'sche Verhandlung, Leipzig.

VACHON, M. (1947): Contribution a l'etude de development post-embryonnaire de *Pachybolus ligulatus* VOGES. (Myriapodes, Diplopodes, Spiroboloides) Les etapes de la croissance. Ann. Sci.Nat.(Zool.), *(11)9*, 109—121.

ACTA BIOL. SZEGED. 34. PP. 177—181 (1988)

THESIS OF DISSERTATION FOR CANDIDATE DEGREE

PREPARATION OF GLYCOLYTIC ENZYMES BOUND TO SOLID SUPPORTS, STUDIES OF THEIR PROPERTIES AND THEIR APPLICATION

L.M. SIMON

Department of Biochemistry, Attila József University, H—6701 Szeged, PO Box 533, Hungary

Introduction

During the 1970-s, there was significant progress in the study of immobilized enzymes: their application seemed to be promising, since they have several advantageous properties compared with the free enzymes. The product is free from the enzyme catalysing its formation, because the enzyme can easily be separated. Following removal of the products, the immobilized enzymes can be employed repeatedly, they are applicable in continuous operation and these factors decrease the costs of operation.

The immobilized enzymes are at the centre of attention as concerns both practical importance and basic research. One of the most interesting fields of interest in biochemistry is that of cellular component organization. The cell is currently envisaged as a highly organized system. Previously, cytosol was generally considered to be a well-mixed but concentrated solution of various enzymes, the latter being located in an ordered form bound to the membranes or coupled to each other to give a multi-enzyme system. It is possible that the enzymes of the glycolytic pathway can be found in complexes associated with the ultra-structure of the cell. Hexokinase was considered to be a soluble enzyme in vivo, but it turned out that it binds selectively to an integral membrane protein in the outer mitochondrial membrane. It has recently been reported that glycolytic enzymes of rat skeletal muscle associate with actin filaments. For study of the operation of enzymes catalysing consecutive reactions, one posibility is the attachment of these enzymes to different supports, the preparation of immobilized enzymes and the investigation of their properties.

The immobilized enzyme systems have been used as a model to study how the organization and the structural environment may affect the activity of an enzyme system. For the investigation of the properties of membrane-bound enzymes, supports possessing a negative charge are applicable, because the membranes are abundant in phospholipids and their natural microenvironment will be negatively charged.

Owing to their acid component, cell membranes, are hydrophobic too. In hydrophobic methyl acrylate and other synthetic gels, the hydrophobic microenvironmental effects can be studied.

It is recognized that the covalent binding of a homogeneous enzyme to a supporting matrix can give rise to a highly heterogeneous preparation. The enzymes can be bound differently to the matrix, but the enzymes are also associated with the surfaces in different ways in the cell. The enzyme activity is influenced by the surrounding microenvironment both in vivo and in vitro.

THE AIMS OF THIS WORK WERE:

A) to compare the efficiencies of different covalent immobilization methods in the case of glycolytic enzymes;

B) to study the catalytic properties and stabilities of immobilized enzymes prepared by the most efficient method, and to demonstrate whether there are general consequences involved in the differences measured between soluble and immobilized enzymes; and

C) to study the practical applications of immobilized enzymes having appropriate stability, primarily for analytical purposes, for the quantitative analysis of intermediates.

Materials and Methods

Enzymes were prepared and purified according to the literature procedures. The protein determinations were carried out by the method of LOWRY and BRADFORD.

For the preparation of immobilized enzymes, Sepharose 4B, silica-based Silochrome aldehyde and the polyacrylamides Akrilex P 100 and Akrilex C 100 were used. The Sepharose 4B was activated with cyanogen bromide, and the enzymes were coupled to the activated gel in 0.1 M $NaHCO_3$ solution, pH 8.0. The immobilization on Silochrom aldehyde was performed according to RYAN and FOTTRELL at pH 8.0. The enzymes were attached to Akrilex P 100 after activation with p-benzoquinone.The activation method was developed in our Deparment. The carboxyl groups of Akrilex C 100 were activated with water-soluble carbodiimide and the enzymes were coupled to the activated support. The non-covalently bound protein molecules were removed from the support by washing with buffer containing 1.0 M sodium chloride. The enzymes were generally stored in 0.1 M triethanolamine buffer (pH 7.6) until use.

The enzyme activities were determined with a Varian spectrophotometer (DMS 70). The activities of the immobilized enzymes were measured in the same reaction mixture as used for the activity determinations of the soluble enzymes. The reaction mixture was stirred for an appropriate time, the enzyme was filtered off quickly and the changes in the filtrate were determined.

The pH-dependence of the enzyme activities was studied in 0.1 M buffers between pH 5 and 12. The temperature-dependence of the enzyme activities was measured in the range 25—65°C.

The heat-inactivation of the enzymes was followed between 35 and 60°C, in temperature steps of 5°C.

The application of immobilized enzymes for analytical purposes was studied with enzymes bound to Akrilex C, both in batch and in flow injection system.

Summary of the new scientific results

Active immobilized forms of five glycolytic enzymes were prepared using different methods. The enzymes were bound to the support through nucleophilic amino groups. The activities of the enzymes coupled to different polymers showed diffe-

rences, but there was a definite sequence as regards the efficiency of the various methods.

The enzymes bound to Silochrome aldehyde had the lowest activity, which meant that the Silochrome support was not suitable for the immobilization of these enzymes.

Better results were achieved when agarose and Akrilex P activated with p-benzoquinone were used for the immobilization of the enzymes. The highest activities were those of the enzymes attached to Akrilex C, after activation of the carboxyl groups with watersoluble carbodiimide. The former enzymes were studied profoundly and the properties of the immobilized enzymes were compared with those of the soluble enzymes.

It was found that the pH-dependence of the immobilized enzymes differed from that of the soluble enzymes. The pH optima of imobilized hexokinase and pyruvate kinase were shifted in the alkaline direction to extents depending on the ionic strength of the medium. Even at an ionic strength of 0.2, the pH shift was about 0.5 pH unit. For 3-phosphoglycerate kinase, the soluble enzyme had a characteristic broad pH optimum range, while the activity of the immobilized form exhibited a relatively sharp pH optimum. No difference was measured between the pH optima of soluble and immobilized lactate dehydrogenase and glucose-6-phosphate isomerase.

It was demonstrated that the apparent temperature optima of the immobilized enzymes were shifted to higher temperatures (hexokinase and lactate dehydrogenase) or the immobilized enzyme showed a broader apparent maximum range (3-phosphoglycerate kinase and pyruvate kinase). The immobilized glucose-6-phosphate isomerase displayed a slightly lower apparent temperatura optimum than the soluble one.

The Michaelis constants of the soluble and immobilized glycolytic enzymes were determined and it was found that the values for some substrates were increased, while for others they were decreased. For 3-phosphoglycerate kinase with both substrates, for pyruvate kinase for ADP, and for hexokinase with ATP the values of $K_{M\ app}$ were decreased relative to those for the soluble enzymes. In all other cases, the apparent Michaelis constants of the immobilized enzymes were higher than those of the soluble enzymes.

The kinetics of the heat-inactivation of the soluble and immobilized enzymes was studied in detail. In most cases the heat-inactivation revealed complex phenomena (hexokinase, immobilized lactate dehydrogenase, glucose-6-phosphate isomerase and 3-phosphoglycerate kinase). The thermal inactivation of soluble lactate dehydrogenase, and immobilized and soluble pyruvate kinase followed first-order kinenetics.

The higher stabilities of the immoblized enzymes compared to those of the soluble enzymes were found in the kinetics of inactivation in the presence of urea. The changes in enzyme activity during the incubation period exhibited results similar to those in the heat-inactivation. Soluble and immobilized pyruvate kinase gave unusual results; both were inactivated according to two apparent first-order

kinetic reactions. It was remarkable that not only the rate constants, but also the amounts of rapidly inactivating molecules, were affected by the urea concentration applied.

For some enzymes (hexokinase and glucose-6-phosphate isomerase), but in particular 3-phosphoglycerate kinase, an activation was observed during the initial phase of heat and urea treatment.

The operation of enzymes bound to Akrilex C was studied in a column reactor and the optimal substrate concentrations were determined. In particular, the pyruvate kinase and lactate dehydrogenase reactors showed good transformations of the substrates, because the conversions of these reactors decreased only slightly when the flow rate was increased from 5 reactor volumes per hour to 50 reactor volumes per hour.

Reactor systems applicable for analytical determinations were constructed. The two immobilized enzyme system (hexokinase and glucose-6-phosphate dehydrogenase) can be used for the determination of glucose and ATP, while the three-enzyme system (the former two plus glucose-6-phosphate isomerase) is applicable for quantitative analyses of fructose.

Immobilized pyruvate kinase and lactate dehydrogenase can be used to perform quantitative measurements of phosphoenolpyruvate and pyruvate in both batch and flow-through cell systems.

Practical importance of the results

First of all, the presented experimental results increase our knowledge about immobilized enzymes and promote further research in this field. The immobilized enzymes having good operational stability afford a possibility for the performance of analytical determinations. The analytical systems mentioned above can be extended to other intermediates, through the use of one further immobilized enzyme.

The flow injection system gives a possibility for relatively simple and accurate measurements. The time used for measurements can be shortened by using several immobilized enzyme columns connected in parallel.

Certain substrates can be produced on a preparative scale with immobilized enzymes, and it is a very significant fact that optically active forms of substrates can be prepared in this way, while the less expensive synthetic procedure gives optically inactive compounds.

Selected publications relating to the dissertation

SIMON, L.M., NAGY, M., ÁBRAHÁM, M., SZAJÁNI, B. and BOROSS, L.: Comparative studies on soluble and immobilized yeast hexokinase. — Enzyme Microb.Technol. 7, 275—278, 1985.

SIMON, L.M., SZELEI, J., SZAJÁNI, B. and BOROSS, L.: Immobilization of pig muscle 3-phosphoglycerate kinase. — Enzyme Microb.Technol. 7, 357—360, 1985.

SIMON, L.M., KOTORMÁN, M., SZAJÁNI, B. and BOROSS, L.: Comparative studies on soluble and immobilized rabbit muscle pyruvate kinase — Appl. Biochem. Biotechnol. *11*, 195—205, 1985.

SIMON, L.M., GULYÁS, Á.M., DEÉR, K.A. and BOROSS, L.: Studies on the immobilization of glycolytic enzymes. — Zagadnienia Biophizyki Wspólczesnej *10*, 107—114, 1985.

SIMON, L.M., KOTORMÁN, M. and BOROSS, L.: Comparative studies on soluble and immobilized rabbit muscle pyruvate kinase. — Acta Biochim. Biophys. Acad. Sci. Hung. *19*, 63, 1984.

SIMON, L.M., KOTORMÁN, M., SZAJÁNI, B. and BOROSS, L.: Preparation and characterization of immobilized glucose phosphate isomerase. — Enzyme Microb. Technol. *8*, 222—226, 1986.

KOTORMÁN, M., SIMON, L.M., SZAJÁNI, B. and BOROSS, L.: Immobilization of lactate dehydrogenase on polyacrylamide beads. — Biotechnol. Appl. Biochem. *8*, 53—59, 1986.

SIMON, L.M., KOTORMÁN, M., SZAJÁNI, B. and BOROSS, L.: Immobilized pyruvate kinase and lactate dehydrogenase reactors. — Biol. Chem. Hoppe—Seyler *367*, 360, 1986.

SIMON, L.M., KOTORMÁN, M., BOROSS, L. and SZAJÁNI, B.: Determination of intermediers of glycolytic pathway in a flow-injection system using immobilized multienzyme reactors. Biotechnol. Appl. Biochem. (in press)

ACTA BIOL. SZEGED. 34. PP. 183 (1988)

THESIS OF DISSERTATION FOR CANDIDATE DEGREE THE INTERACTIONS OF EVOKED POTENTIAL IN THE POLYSENSORY CORTEX OF CAT AND RAT

J. TOLDI

Department of Comparative Physiology, Attila József University
H—6701 Szeged, P.O. B. 533. Hungary

The author elaborated a method which is suitable for examination of interactions between cortical evoked potentials in polysensory areas of the cerebral cortex.

It has been shown that the main type of interaction between somatosensory and acoustic potentials is occlusion, although sometimes also facilitation occurred. The direction and depth of interactions proved to be variable from point to point and characteristic for the locus examined. The interactions due to each site could be shifted towards occlucion by a.) elevating the stimulus frequency, b.) stimulating the mesencephalic reticular formation, c.) administering propranolol (a beta adrenergic blocker), gamma amino-butyric acid, Baclofen or diazepam. The occlusion manifested itself in all these cases by decrease of the summated response. Sometimes this attained such a degree that the summated response was smaller than each of the constituents.

A shift towards facilitation was observed when amphetamin or bicucullin was administered. This was usually due to enhancement of the summated response.

It was concluded that in case of occlusive interaction the inhibitory interneuronal system, in case of facilitatory interactions the excitatory interneuronal system became activated.

Extracellular microelectrode recording revealed the existence of five types of neurons which possibly participate in the interactions described above. Factors interfering with interactions of evoked potentials influenced unit activity in a characteristic manner. The polymodal units proved to be plastic in their behaviour: the same influences which were effective on evoked potentials, modified their firing activity, too.

On the basis of experimental observations a functional model of polysensory cortices could be constructed with special emphasis on the interneuronal system of cortex, as target structure of the specific and non-specific afferent fibers.

ACTA BIOL. SZEGED. 34. PP. 185—186 (1988)

THESIS OF DISSERTATION FOR CANDIDATE DEGREE

THE GLYCINE LABELLING AND ITS APPLICATION IN THE CENTRAL NERVOUS SYSTEM

I. ROJIK

Department of Comparative Physiology, Attila József University
H—6701 Szeged, P.O.B. 533 Hungary

The incorporation of amino acids into proteins of the central nervous system was studied in various functional states. The most typical experiment was the following: filter paper strip soaked in isotopically labelled amino acid solution was placed on some selected area of the cerebral contrex (or spinal cord) and kept there for 1—2 hours. During incubation the nervous structures, underlying to the applied amino acid, were stimulated in physiological way: the acoustic cortex was stimulated with click impulses or pure tones via the ears; the somatosensory cortex was stimulated with electric shocks applied to different points of the body, and the visual cortex was excited by flash stimuli given to one or both eyes. After the incubation period the cortical structures were excised, rapidly fixed in Karnowsky or Bouin solution and processed forther for light and/or electron microscopic autoradiography. The exposition time was 11 weeks.

Experiments were carried out also on the cerebellar cortex, hippocampus and spinal cord. Cats, rats and frogs were used in the experiments.

After application of labelled glutamic, aspartic acids and leucin a diffuse incorporation was found in case of glutaraldehyde fixation. The same was seen with glutamic, aspartic and gamma aminobutyric acids after Bouin fixation. Cellural localization of the incorporated amino acids was seen in case of leucin and glycine with Bouin fixative. Stimulation of the respective cortical area decreased the incorporation of leucine and enhanced the incorporation of glycine. For further studies therefore glycine was choosen, because its incorporation seemd to be in good correlation with the functional state. After Bouin fixation glycine remained incorporated only in nerve cells, while after glutaraldehyde fixation some labelling also in glial cell could be observed. First the effect of waking state was systematically studied on glycine incorporation into the cat cerebral cortex, then it was examined at different levels of anaesthesia. In waking state 32,5% of the neurons, stainable with haematoxylin-eosin, appeared labelled in the acoustic cortex of the cat, without any sensory stimulation. In light barbiturate anaesthesia this proportion was 20,7%, at medium depth of narcosis 10,1%, in chloralose anaesthesia this made 4,4%. In such spontaneous activity the labelling of upper layers was more intensive, that of the deeper (IV—VI) layers was less intensive than the overall proportion of labelled cells. This tends to show that impulses maintaining the resting activity of the cortex are mediated by the superficial layers (I—III).

Sensory stimulation resulted in an unaequivocal increase of labelling in the somatosensory, acoustic, visual and motor cortices, either.

In the somatosensory cortex stimulation of the skin of elbow or vibrissae led to significant labelling of layers IV—VI, especially of pyramidal cells in layer V and labelling of layer I—III became more intensive. In case of vibrissal stimulation the columnar organization of cortex was reflected by the autoradiographic labelling. Electrophysiological records taken from focal and extrafocal points of the somatosensory cortex were parallelled by the extent of glycine incorporation.

At very moderate electrical activity the motor cortex exhibited a considerable autoradiographic labelling in resting state. During stimulation of the ventrolateral nucleus (VL) of the thalamus triphasic evoked potentials appeared on the cortical surface. The glycine incorporation became enhanced in all cortical layers. During pyramidal tract (PT) stimulation the cortical electrical activity was depressed and glycine incorporation seemd to be restricted to some pyramidal cells and a small group of interneuron in layers II and III. This might be the sign of an irradiated cortical inhibition caused by the recurrent pyramidal axon collaterals. The experiment was performed both in barbiturate and chloralose anaesthesia and cell counts obtained with PT and VL stimulation gave an overall picture about extension of excitation and inhibition during the first steps of information processing.

Stimulation of the auditory cortex with pure tones in the frequency range of 0.33 to 30 kHz gave opportunity to construct the tonotopic map with the aid of the glycine labelling method.

Application of this procedure helped to differentiate two polysensory association areas in the suprasylvian gyrus of the cat.

During stimulation of the VA nucleus of thalamus a widespread labelling was encountered in the primary sensory, motor and associational areas of the cat cortex.

Stimulation of the inferior olive resulted in a well defined inhibition in the cerebellar cortex and in appearance of Purkinje cells in regular distanses.

Combination with the experimental paradigm of long term potentiation in the rat hippocampus led to the conclusion that the intensification of glycine incorporation in the dentate gyrus may be the morphological equivalent of the long term potentiation.

The glycine labelling method was successfully applied also for investigation of neuronal protein transport and of the information processing in the spinal cord.

ACTA BIOL. SZEGED. 34. PP. 187—193 (1988)

THESIS OF DISSERTATION FOR ACADEMIC DOCTOR DEGREE

SOMATIC DEVELOPMENT AND AGE AT MENARCHE OF 10—18 YEAR OLD GIRLS OF SOUTHERN HUNGARY

GY.L. FARKAS

Department of Anthropology, Attila József University
H—6701 Szeged. P.O.B. 660. Hungary

(Received: June 30, 1987)

I. Theme of the research, antecedents and aims

Two very important processes are taking place in man's postnatal life concerning his/her later fitting in society: sexual and social maturation.

The chronological interval between the expiry of them has increased mainly because sexual maturation has been assigned to an earlier age in the last few decades in Hungary, too.

Sexual maturation supposes that young people are educated and informed in this field. As a result they acquire ability and a form of behavior that are necessary lead to a balanced way of life.

The question is, however, when to begin sexual education at school as well as how deep and graded it has to be. It can't be regulated by rules valid for ever. On the basis of the above mentioned considerations it is necessary periodically to control the time of pubescence and the education and information have to be changed according to needs. New relations are to be discovered to carry on this work, and partly this can be solved with human biological research influencing pubescence. Man is a biological and social being at the same time, social factors also have to be taken into account.

Man's sexual maturation is a complicated process regulated by neurohormon system. An experimental research of healthy young people with a large number of sampling can't be carried out because of several reasons. So girls' first menstruation (menarche) and boys' first ejaculation time (pollution) are examined. As the observation of the latter is very uncertain we can get some information about the beginning of pubescence on the basis of studying menarche.

The first foreign study about menarche is connected with the name of HALLER (1775), and in Hungary SEMMELWEIS was the first man to publish data (1860). To study it we have three possibilities: status quo, the prospective and retrospective methods (FALKNER and TANNER, 1978). The first involves the second one as well, and can be considered the best method of collecting data; in spite of this, status quo method is used by most of the researchers since the study of a population requires at least 8—9 years.

It is difficult to compare the results because the methods of evaulation are different. Results got by the probit analysis (WEBER, 1961) have been considered to be the best during the last few decades. The girls' pubescence has been examined in connection with some factors. They can be divided into three groups: endogenic factors having close connection with girls' biological being, exogenic factors that can be either natural or social, and at last endogenic and exogenic factors have conjugate effects.

All these factors have not been examined simultaneously with the same population on large samples.

As in normal circumstances menarche begins in Hungary between the age of 8—16 (SAS and KOVÁCS, 1984) from methodological points of view it seems to be enough to begin to collect data in the senior classes of the primary school, and to study several factors simultaneously is most expedient concerning menarche of girls between the age of 10—18 with the help of anonymous questionnaire method.

Taking into consideration the experiences of special literature home and abroad we set the following aims:

— collection of large, random, representative sampling of girls between 10—18 living on one geographical area (County Csongrád, Southern Hungary);

— in order to make comparison easier samples have to be taken in other parts of the country as well;

— collection of data concerning the given age-groups has to be extended to pupils of primary, secondary and vocational training schools as well;

— in order to define boys' physical development, their body weight, body height and normal chest circumference have to be determined, only this way we can get a real picture of the physical development of boys and girls;

— collection of data — because of the above mentioned aims — has to be extended slightly to the age groups of younger than ten years old;

— all the factors having been examined before should be in the programme of research;

— the results of the research are to give possibility for a critical evaluation of questions of theoretical importance;

— on the basis of the results the order of factors influencing pubescence are to be established;

— the results have to help sexual education at primary school as well as its succession in time.

II. Sample and methods

For our research we made questionnaires suitable for computer processing both for boys and girls. The girls' menarche questionnaire contained 32 questions, 3 of wich directly aimed at menarche time.

There were 22898 boys and 32156 girls in the sample.

The great majority of sample has been derived from County Csongrád but some samples have been collected in the northern part of Hungary, in Transdanubia and in the territory east of river Tisza. This work was done by the co-workes of Department of Anthropology of A.J. University and the Public

Health and Epidemiology Station of County Csongrád. This research was carried on as a state assignment topic and sponsored by the Ministry of Health and Ministry of Cultural Affairs.

We used the MARTIN and SALLER auxological anthropological technique (1956), somatoscopic observations were carried on according to TANNER (1962) with the help of Harpenden instruments, scale and colour scale. Pupils were wearing gym suit, while establishing the development of secondary sex characteristics schoolgirls of primary school took it off.

Observations and measurements according to the different characters i.e. collection of data were made by the same persons between 1981 and 1984. To establish skeletal maturity radiograph was taken of the left hand of a limited number of boys and girls. They were evalued by TW 2 method (TANNER et al., 1975).

Coding was made by the same two persons, certain questions were coded by the same person. In some questions such as occupation of parents, size of domicile definite categories were established for sake of uniformity.

The evalution was made by the László Kalmár Cybernetic Laboratory using Osiris program by Computer R-55.

IBP decimal table was used to calculate age then half year age-grouping was made.

Secondary sex characteristics were evaluated by the 12 point method by SCHWIDETZKY.

Concerning auxological characters the most important parameters (n, $\bar{x}$, s, w) were calculated according to sex and half year age-groups, with the help of which normal ranged ($\bar{x} \pm 1.96s$) were formed to estimate physical development. Subsamples made according to different viewpoints were comparted by two-sample Student's test on 95 p.c. probability level. After standardization further analysis was carried on by variance analysis based on variance ratio test.

According to the examined factors the medians and 95 p.c. confidence intervals belonging to them were defined by probit analysis. The order of succession of factors was defined by and additive predictive model.

III. Summary of results

1. PHYSICAL DEVELOPMENT

The physical development of both sexes can be said to be good but the rate overweight pupils is of high percentage. The means of body weight and body height show further increasing while the means of average chest circumference are decreasing.

The physical development of apprentices of both sexes is significantly worse than that of secondary school pupils, the difference in case of girls is less than at boys.

As for girls significant differences cannot be found in body weight, normal chest circumference, biiliac diameter and birth weight on the basis of distance from the place of birth of parents. The body height of children of parents from further domicile is higher, and significant differences can be observed especially in pubescence and postpuberty.

No marked differences can be determined in the average of body measurements of the young living at domiciles of different sizes. At the same time the effect of urbanization on girls is stronger.

Significant differences in the body messurements of boys living in different parts of the country can only be found in different age-groups and mostly in stature what it may be due to ethnical differences. The differences in girls' age-groups are bigger and in all the three measurements the frequency is nearly the same.

2. GIRLS' PUBESCENCE

The median of the whole sample is 12.79 years, and the corresponding confidence interval is between 12.46 — 13.11 years. Menarche-median in Hungary has decreased by 0.41 years compared with that in the 1960—ies (BOTTYÁN et. al., 1963).

The average of auxological characters of the examined postmenarcheal girls is higher than that of the non-pubescent. At the same time the age of maturation can't be joined with a critical body weight as the lack of menstruation occurs with girls with large body weight, but there were girls with low body weight and their menarche began.

The medians of secondary sex characteristics are the following: median of telarche 12.44 years, that of pubarche and axillary hair 12.60 years.

There is no significant connection between the colour of the eyes and menarche. What for the colour of hair and menarche it can be supposed that girls having dark hair mature earlier while girls with light-coloured hair later.

The relation between skeletal maturity and menarche is closer than that between menarche and chronological age. But this has only been controlled on a small sample.

Coincidence between the year of menarche of girls and mothers can only be expected in 28 cases out of 100.

Coincidence between the month of menarche of girls and mothers (super-coincidence) cant't be expected in most cases.

Between the arithmetic mean of the absolute menarche-age of mothers and of their daughters there is one year difference; the pubescence of the latter began a year earlier. There is not any significant difference between the median and the arithmetic mean in a large sample. If the two arithmetic means in mother's and daughter's relation are known, the results obtained by the status quo method can be compared in case of the retrospective method for collecting menarche data.

Together with the increase of the distance between the place of birth of parents to 200 kms the median increases, but the difference is so little that on this basis we can't speak about a heterosis effect.

Though the secular trend of menarche can be observed in Hungary but its pace has slowed down lately and it indicates that we have reckon with a deceleration. On comparing the country-wide medians we can realize that the predicted decrease of the menarche-median in a 3—5 month decade can't be observed. We can get more reliable information on the tendency of a changing median if we examine it on the basis of the girls' date of birth. But as in our case as well, it requires a large sample.

The median changes according to the order of succession of birth, the first born children reaching puberty earlier than the second and the third born girls.

There isn't significant relation between the father's and mother's age and the time of maturation. But if both parents are older and they are of the same age their daughter reaches pubetry later.

Light and the meteorological phenomena connected with it have some effect on the time of maturation, they stimulate the menarche to begin earlier.

There is a positive correlation between the height above sea level of the domicile of girls and the time of maturation, as the girls living on higher domicile reach puberty later. This can be noticed even if the difference is only a few hundred meters.

There is some relationship between the education level of parents and their daughter's time of maturation: the lower is the level of the parents' education, the later their daughter reaches puberty.

Daughters of mothers and fathers with intellectual occupation (graduates of university, college or secondary school) begin to menstruate earlier than those of parents occupied as industrial, agricultural or other physical workers.

The higher the number of living brothers or/and sisters of a girl the later her menarche begins. This relationship is more valid with 0—5 sisters.

If the average achievement of the girls is worse then their menarche-median is 0.2 years higher than that of the girls whose achievement is better.

On the basis of the size of domicile (number of inhabitants) we can establish that the menarche-median of the girls living on a domicile with more inhabitants is lower than on a smaller domicile. On the domicile with 200.000 to 5.000 inhabitants it shows an ever increase but girls living on a domicile less than 5.000 reach puberty earlier.

Menarche shows seasonality as most of the inquired girls began to menstruate either in winter or summer. In case of mothers only the summer maximum can be verified.

The above mentioned results correspond to earlier experiences in Hungary and abroad though in parts there are some differences as well.

It can be supposed that the biannual cups of distribution curve of menarche-age experienced at human beings has developed during the evolution and it may have connection with the sexual seasonality observed with lesser breeds of Primates order.

Significant similarity between the month of menarche of mothers and of their daughter's has not been supposed.

Coincidence between the month of menarche and that of birth of girls could be found in 11.08 p.c.At the same time there is no mathematical correlation between the two variables, and on this basis it can be concluded that the month of birth doesn't determine the month of menarche.

The menstrual cycle of 18 p.c. of girls didn't become regular in 1—2 years after the menarche began.

52—53 out of 100 pupils have got information from their parents on problems concerning pubescence. And it means that the 10—18 year old girls' sexual education cant't be regarded to be satisfactory. From this point of view different relative frequency can be established in different parts of the country.

The order of significance of factors examined by the additive predictive model is as follows:

year of birth of inquired girls;

size of domicile (number of inhabitants);

county of girls' domicile;
number of living sisters;
occupation of mother;
age of mother at the time of daughter's birth;
number of living brothers;
the order of birth of the girl;
occupation of father;
the distance between the place of birth of parents;
the colour of the girl's hair.

IV. New results

Collecting auxological and somatoscopic data was carried on by the same persons in the whole research in order to avoid making mistakes surveying was carried on by one, and observation by another person what is very difficult at large number of samples.

As far as we know it was the first case in Hungary or even abroad when menarche and the connection of 32 factors as well as the development of secondary sex characteristics have been studied simultaneously with the same population at about 32.000 girls.

We tried to systematize all the factors connected with menarche and mentioned in special literature.

From methodological point of view it's quite a new thing to compare menarche-median with average of menarche (calculated from the chronological age at menarche at the same sample). So the collected data by the retrospective and status quo methods can be compared.

Auxological anthropological characteristics (boys' body weight, body height, normal chest circumference, and at girls biiliac diameter and birth weight) as well as the change of the menarche-age of girls on the basis of the distance between the place of birth of parents could be first analysed on a Hungarian sample. On this basis the heterosis effect at the occurrence of menarche can be disputed.

The menarche-median decrease by 3—5 months in a decade can't be supposed, at Hungarian girls even a deceleration can be reckoned with (menarche-median is rising again, and girls reach puberty later).

The menarche biannual occurence can presumably be connected with the process of anthropogeny being accomplished by reproduction.

The great number of factors being examined simultaneously with menarche made it possible to arrive at a conclusion concerning their order of significance.

The order of importance of factors is a good basis for establishing an evaluation factor, with the help of which the girls' menarche time can be predicted with 3—4 month accuracy. This method, however, still needs further improvement.

V. Practical utilization of results

The regularities based on the factors that can be connected with menarche as well as the knowledge of the order of significance of factors makes it possible to define the exact time of the beginning of the sexual education in the school. So it is definitely necessary to give girls informations about sexual hygeny in the second half of the sixth class and in the first half of the seventh class in the primary school.

The time of menarche can be predicted by the coefficients calculated by additive predictive model.

Results of menstrual cycle concerning its regularity as well as the information about the development of secondary sex characteristics can be very useful for pediatric gynaecology. At the same time the sample of examination can be considered as a control in pediatric gynaecology concerning teenagers.

ACTA BIOL. SZEGED. 34. PP. 195—196 (1988)

CHRONICLE

Personalia

The Council of Ministers was appointed Dr.GY.FARKAS to professor of Department of Anthropology.

The Minister of Culture and Education was appointed to assistant professor DR. MÁRIA NAGY (Department of Plant Physiology), DR. MÁRIA SIMON (Department of Biochemistry), to honorary professor DR. I.PÁLYI (Department of Biochemistry) and DR. E. LEHOCZKI to honorary assistant professor (Department of Biophysics).

DR. J. NEMCSÓK was charged to direct the Department of Biochemistry by the Minister of Culture and Education.

Awards

Professor DR. L. OROSZ (Department of Genetics) was awarded an academic prize for his outstanding scientific work.

Assistant professor DR. Z. VÁRKONYI was medailled with the Silver Degree of Honour-Work.

Scientific degrees

The degree of candidate in biological science was obtained by:

DR. G. LASKAY (Department of Biophysics) with his dissertation: The organization of the photosynthetic apparatus in modified chloroplast membranes.

DR. I. ROJIK (Department of Comparative Physiology) with his dissertation: The glycine labelling method and its application in the central nervous system, and

DR. MÁRIA SIMON (Department of Biochemistry) with her dissertation: Preparation of glycolytic enzymes bound to solid supports, studies of their properties and their application.

Varia

Anatomical Days was organized by the Antomical Sub-Commission of Botanical committee of Hungarian Academy of Sciences in Szeged at 29.August 1988.

The 5th Hungarian Plant-Anatomical Symposium on 25—26 August 1989 will be organize by the Anatomical Sub-Commission of Botanical Committee of Hungarian Academy of Sciences in Szeged in the Department of Botany. On the first day of Symposium we will commemorate the pupil of the outstanding tree-anatomy Prof.

DR. PÁL GREGUSS from his life and scientific work on the occasion of 100 year anniversary of his birth.

Honorary professor DR. M. KEDVES was elected to the Hngarian Committee of ICSU International Geosphere—Biosphere Program (IGBP).

Notice

On the 4th of June 1987 the Attila József University Council created a commemorative plaque on the occasion of the centannial of LAJOS BARTUCZ's birth, he was a professor of our University.

The 12.2 cm diameter plaque was designed and made by sculptor ANDRÁS LAPIS in Szeged. On the rim of the plaque a quotation by OMAR KHAJJAM reads: "A perpetual secret only of man remains: why does man live if he must die? And why must man die if he has lived?"

The University Council will make this award every one or two years to the Hungarian or foreign physical anthropologist, who has displayed outstanding activity in the area of anthropology developing an international connection with the Department of Anthropology of Attila József University.

Index